

PRELIMINARY TEST RESULTS OF THE ELECTRONIC SWITCHING SPHERICAL ARRAY ANTENNA

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ABSTRACT

An Electronic Switching Spherical Array (ESSA) Antenna has been developed for low orbiting spacecraft requiring medium gain (+13 dBic) transmit and receive relay capability through the Tracking and Data Relay Satellite Systems (TDRSS). This 145 radiating element antenna is steered with a microprocessor controller by selecting arrays of 12 elements at a time. Approximately 1800 beams can be selected for near hemispherical coverage. The primary method for evaluating this antenna is a composite Radiation Distribution Plot (RDP).

INTRODUCTION

The Electronic Switching Spherical Array (ESSA) is a general class of antenna having medium gain throughout a large coverage region, typically π steradians. The ESSA described herein is for the purpose of transmitting and receiving data on the Earth Radiation Budget Satellite (ERBS) through the Tracking and Data Relay Satellite System (TDRSS). Design, fabrication and qualification tests are funded by NASA/GSFC.

This ESSA was described in a paper given at the 1982 International Conference (Reference 1). The following paragraphs provide updated photographs of the flight hardware, describe test methods of the ESSA, and give some preliminary test results.

ESSA DESCRIPTION

Figure 1 is a photograph of the 30-inch diameter ESSA, which contains 145 disk radiating elements. The heart of the ESSA is a Switching Power Divider (SPD) which selects 12 radiating elements at a time to form a beam in the desired direction. Figure 2 is a photograph of the SPD with an RF cable for each radiating element. Figure 2 also shows the structure to which the spherical array mounts and a wire basket to support the coaxial cables. Not shown is the electronics which tells the SPD which 12 elements are to be

selected. The electronics consists of a microprocessor controller and a driver. The controller calculates the relative position of the ERBS and the TDRS and determines the desired look angle. The driver provides bias to pin diodes inside the SPD to select the appropriate elements.

TEST RESULTS

The ESSA with its 145 radiating elements is capable of generating at least 1800 beams over a hemisphere. One of the more interesting problems is evaluating the performance of such an antenna. This was done by generating a composite Radiation Distribution Plot (CRDP). A CRDP is a composite of the peak gain of all beams.

To accomplish this task, an antenna range computer and the ESSA microprocessor controller are both used. The antenna range computer operates in a standard RDP mode. This master computer sends pointing angles to the ESSA controller. The ESSA controller instructs the ESSA to form a beam in the appropriate direction. The ESSA controller also acknowledges that pointing information was received or the systems shuts down. The resultant CRDP is a printout every degree in ϕ and θ .

Figure 3 is a reproduction of a 30° by 57° section of this CRDP. It will be noted that the gain in the region shown is relatively constant varying from 14.1 dBic to 11.3 dBic. This is typical of the ESSA performance for 360° in azimuth and 82° in elevation at the first turn-on prior to optimization.

Another parameter of the ESSA of interest is the relative phase from beam to beam. This is measured in the same manner with a 30° by 57° section shown in Figure 4. The phase is relatively constant varying less than 10° from point to point over the scan region.

Figure 5 is a photograph of the test Controller for the ESSA. The Controller has several modes of operation. There is an AUTO mode which was described above for running CRDPs. There is a mode where by a value of ϕ and θ is entered via the keyboard and the Controller selects a group of 12 radiating elements which forms a beam nearest to this value of ϕ and θ . With a third mode, a single radiating element can be selected via the keyboard. Another mode automatically steps through 20 standard beams. These standard beams assure that every radiating element is used at least once for quick look testing. The dome on the Controller contains an LED for every corresponding radiating element.

REFERENCES

- (1) Kudrna, Ken and Hockensmith, Richard P., 1982, "The Electronic Switching Spherical Array (ESSA) Antenna For The Earth Radiation Budget Spacecraft (ERBS)", International Telemetry Conference 1982 Proceedings, San Diego, California, Volume XVIII, pages 271-288.

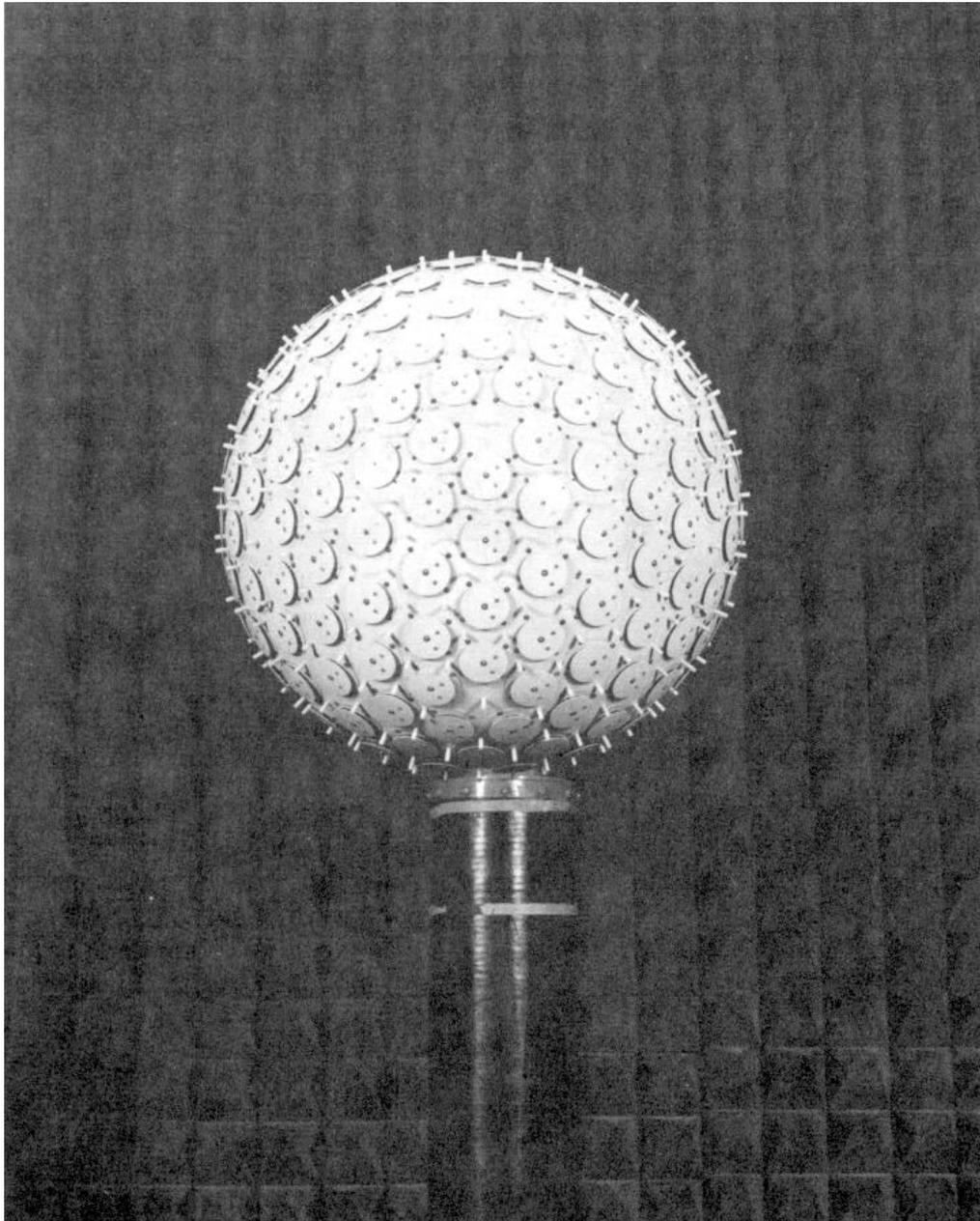


Figure 1. 30-Inch Diameter ESSA

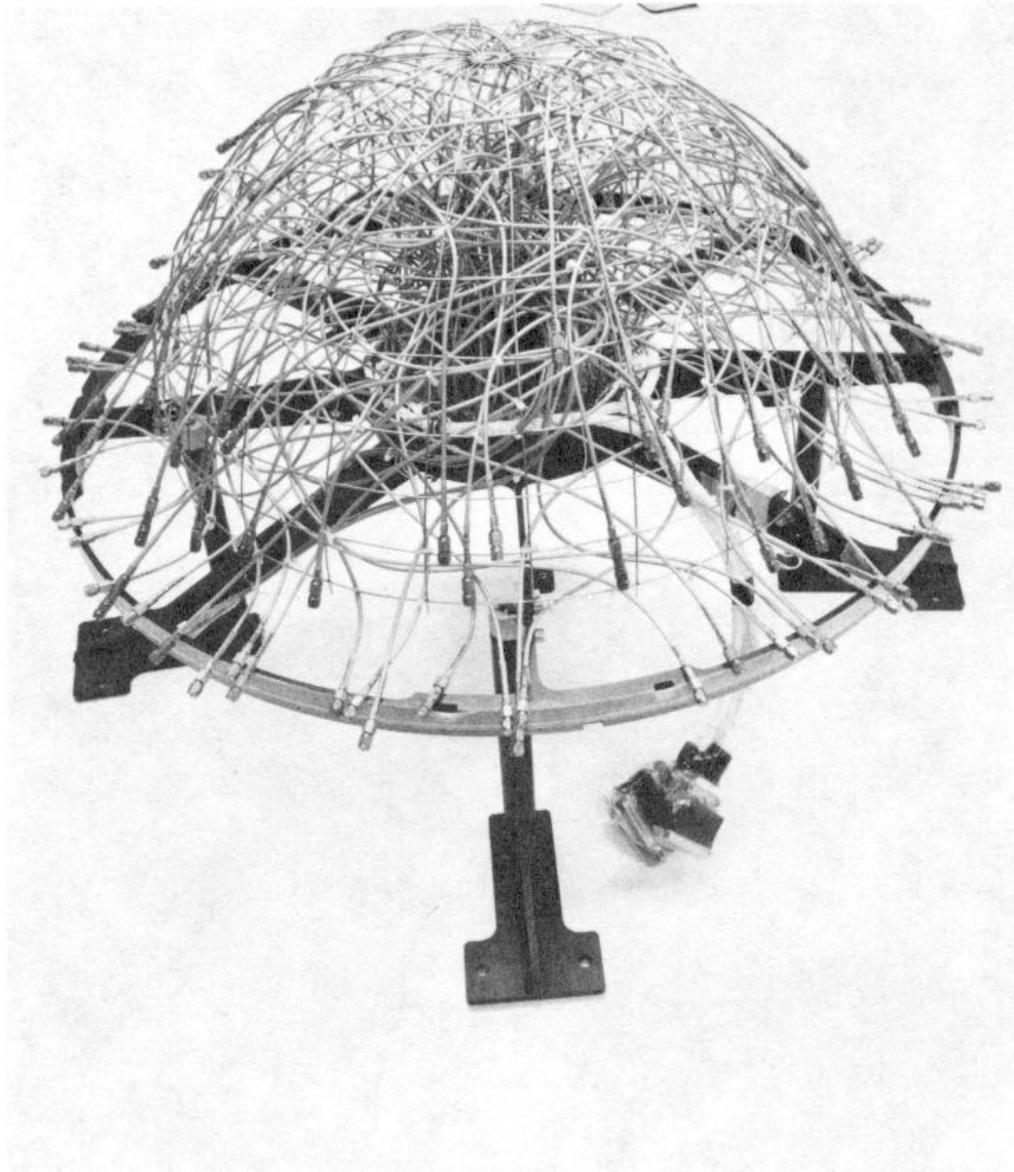


Figure 2. SPD With RF Cables

PHI DEGREES	THETA DEGREES																														
	0	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	
0	+136	+141	+141	+141	+140	+139	+127	+126	+127	+128	+130	+128	+122	+123	+123	+124	+124	+123	+119	+119	+118	+117	+115	+114	+116	+115	+113	+116	+118	+119	
1	+136	+141	+141	+140	+140	+139	+127	+126	+127	+125	+130	+128	+122	+123	+124	+124	+124	+124	+119	+119	+118	+117	+115	+114	+116	+115	+119	+116	+121	+124	
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3	+136	+141	+140	+140	+140	+128	+127	+126	+127	+125	+129	+128	+123	+124	+124	+124	+124	+124	+119	+119	+119	+119	+119	+118	+116	+118	+120	+120	+122	+125	
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48	+136	+134</																													

PHI DEGREES	THETA DEGREES																													
	0	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
0	+43	+43	+44	+46	+46	+47	+50	+47	+48	+48	+48	+47	+43	+46	+48	+50	+52	+54	+54	+57	+57	+59	+59	+60	+61	+62	+61	+63	+63	+65
1	+44	+44	+44	+47	+47	+49	+51	+48	+48	+48	+49	+48	+44	+47	+49	+51	+53	+55	+56	+58	+59	+61	+60	+62	+62	+64	+63	+65	+66	+68
2	+45	+45	+45	+48	+48	+50	+52	+49	+49	+49	+50	+49	+45	+48	+50	+52	+54	+56	+57	+60	+60	+63	+62	+64	+64	+65	+65	+67	+68	+70
3	+46	+46	+46	+49	+49	+53	+53	+50	+50	+50	+52	+50	+46	+49	+51	+54	+55	+58	+58	+61	+62	+65	+65	+67	+66	+66	+66	+69	+70	+72
4	+47	+47	+47	+50	+50	+54	+54	+51	+52	+51	+53	+51	+47	+50	+52	+55	+56	+59	+60	+63	+63	+66	+67	+69	+67	+67	+68	+71	+71	+73
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9	+52	+52	+53	+55	+55	+59	+55	+56	+56	+57	+54	+54	+55	+58	+57	+60	+62	+65	+67	+70	+71	+73	+74	+76	+77	+79	+78	+79	+79	+81
10	+53	+53	+53	+56	+56	+60	+56	+57	+57	+58	+55	+55	+56	+59	+58	+61	+63	+66	+69	+71	+72	+75	+75	+78	+79	+80	+80	+80	+80	+82
11	+54	+54	+54	+57	+57	+58	+57	+59	+58	+60	+56	+56	+57	+60	+58	+60	+64	+65	+70	+73	+74	+76	+77	+80	+80	+82	+82	+83	+82	+83
12	+55	+55	+55	+58	+57	+58	+59	+60	+60	+61	+57	+57	+58	+61	+59	+61	+63	+66	+71	+74	+75	+77	+78	+81	+81	+83	+83	+84	+83	+85
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14	+58	+57	+57	+60	+59	+60	+61	+62	+62	+58	+59	+59	+61	+63	+61	+63	+65	+68	+70	+76	+77	+79	+82	+84	+84	+86	+86	+87	+87	+90
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16	+59	+59	+59	+62	+61	+63	+63	+64	+64	+61	+61	+62	+62	+65	+63	+66	+67	+70	+72	+75	+79	+82	+84	+86	+87	+88	+88	+90	+90	+92
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20	+64	+63	+63	+65	+65	+67	+67	+69	+65	+65	+66	+67	+67	+69	+67	+70	+71	+74	+76	+79	+81	+86	+89	+91	+91	+93	+93	+94	+95	+95
21	+65	+64	+64	+66	+66	+68	+68	+70	+65	+66	+67	+68	+68	+70	+68	+71	+72	+75	+77	+80	+82	+87	+90	+92	+93	+94	+94	+96	+96	+96
22	+66	+65	+65	+67	+67	+69	+70	+71	+66	+67	+68	+69	+70	+71	+72	+72	+73	+76	+78	+81	+83	+88	+90	+93	+94	+95	+95	+96	+97	+96
23	+67	+66	+66	+68	+68	+70	+71	+72	+67	+69	+69	+70	+71	+73	+73	+75	+77	+79	+82	+86	+89	+91	+93	+95	+96	+97	+97	+97	+97	+98
24	+68	+67	+67	+69	+69	+71	+72	+73	+68	+70	+70	+71	+72	+74	+74	+74	+75	+78	+80	+83	+88	+90	+92	+94	+94	+95	+96	+97	+97	+98
25	+69	+68	+69	+70	+69	+70	+72	+72	+69	+71	+71	+72	+73	+75	+75	+74	+76	+78	+81	+84	+89	+91	+93	+94	+95	+96	+97	+98	+98	+100
26	+70	+69	+70	+70	+69	+71	+72	+74	+70	+72	+72	+73	+74	+76	+76	+75	+76	+79	+82	+85	+90	+92	+94	+95	+96	+96	+98	+98	+99	+100
27	+71	+70	+71	+70	+72	+73	+75	+71	+73	+73	+74	+75	+77	+78	+76	+78	+80	+82	+86	+91	+93	+95	+96	+97	+99	+100	+100	+100	+101	+101
28	+73	+71	+72	+72	+71	+74	+74	+76	+72	+74	+75	+75	+76	+78	+79	+77	+79	+81	+83	+87	+92	+94	+96	+97	+98	+100	+101	+100	+101	+102
29	+74	+72	+73	+73	+72	+75	+75	+77	+74	+75	+76	+76	+77	+79	+80	+78	+80	+82	+84	+89	+91	+95	+97	+98	+99	+101	+102	+101	+102	+103
30	+75	+73	+72	+74	+73	+76	+76	+78	+75	+76	+77	+77	+78	+80	+81	+79	+81	+83	+85	+90	+91	+94	+98	+99	+100	+102	+101	+102	+103	+104
31	+76	+74	+73	+75	+74	+76	+77	+79	+76	+77	+78	+79	+79	+81	+82	+80	+82	+84	+86	+91	+92	+95	+98	+100	+101	+103	+102	+103	+104	+105
32	+77	+74	+74	+76	+75	+77	+78	+80	+77	+78	+79	+80	+80	+82	+83	+81	+83	+85	+87	+92	+93	+96	+98	+101	+102	+102	+103	+104	+105	+106
33	+78	+75	+75	+77	+76	+78	+79	+81	+78	+79	+80	+81	+81	+83	+84	+82	+84	+86	+88	+93	+95	+97	+98	+102	+103	+103	+104	+105	+106	+107
34	+79	+76	+76	+78	+77	+79	+80	+82	+79	+80	+81	+81	+82	+84	+85	+83	+85	+87	+89	+94	+95	+98	+99	+101	+102	+104	+105	+106	+107	+108
35	+80	+76	+77	+79	+78	+80	+81	+83	+80	+81	+82	+83	+83	+85	+86	+85	+86	+89	+90	+95	+96	+99	+100	+101	+103	+104	+106	+107	+108	+109
36	+81	+77	+78	+80	+79	+81	+82	+84	+81	+83	+83	+84	+85	+86	+87	+88	+89	+92	+93	+96	+97	+100	+101	+100	+104	+105	+107	+108	+109	+110
37	+82	+78	+79	+81	+80	+83	+83	+85	+83	+84	+85	+85	+86	+88	+88	+90	+91	+93	+95	+97	+98	+101	+102	+101	+103	+106	+108	+109	+110	+111
38	+83	+79	+80	+82	+82	+84	+85	+86	+84	+85	+86	+86	+86	+87	+89	+90	+91	+92	+94	+96	+97	+100	+101	+103	+102	+104	+107	+109	+111	+112
39	+84	+80	+81	+83	+83	+84	+86	+87	+85	+86	+87	+87	+89	+90	+91	+92	+93	+95	+97	+98	+101	+102	+102	+103	+105	+107	+109	+110	+112	+112
40	+85	+81	+82	+84	+84	+85	+87	+88	+86	+87	+88	+88	+90	+91	+92	+92	+94	+96	+98	+99	+101	+102	+102	+104	+106	+107	+110	+111	+112	+113
41	+86	+82	+83	+85	+85	+86	+88	+89	+87	+88	+89	+89	+91	+92	+93	+93	+95	+97	+99	+99	+102	+98	+103	+105	+107	+108	+110	+112	+113	+114
42	+87	+83	+84	+86	+86	+87	+89	+90	+88	+89	+90	+90	+92	+93	+94	+94	+96	+98	+100	+95	+98	+99	+102	+106	+108	+109	+111	+111	+114	+114
43	+88	+84	+85	+87	+87	+88	+90	+91	+89	+90	+91	+91	+93	+94	+95	+95	+97	+99	+101	+96	+98	+100	+102	+107	+109	+110	+112	+106	+109	+114
44	+89	+85	+85	+88	+88	+89	+91	+92	+90	+91	+92	+92	+94	+95	+96	+96	+98	+100	+102	+99	+99	+101	+103	+107	+109	+111	+113	+107	+108	+109
45	+90	+86	+86	+89	+89	+90	+92	+92	+91	+92	+93	+93	+95	+95	+97	+97	+99	+100	+99	+100	+100	+101	+104	+105	+110	+111	+113	+107	+109	+110
46	+91	+87	+88	+90	+90	+91	+93	+93	+92	+93	+94	+94	+96	+96	+98	+98	+100	+98	+100	+101	+101	+102	+105	+106	+111	+109	+112	+109	+110	+110
47	+92	+88	+89	+91	+91	+93	+94	+95	+93	+94	+95	+95	+96	+97	+99	+99	+101	+99	+101	+102	+102	+103	+106	+107	+110	+110	+112	+113	+110	+112
48	+94	+89	+91	+92	+94	+95	+97	+98	+94	+95	+96	+96	+98	+98	+100	+100	+102	+100	+102	+103	+103	+104	+107	+108	+110	+111	+113	+114	+115	+116
49	+95	+90	+92	+93	+95	+96	+98	+99	+95	+96	+97	+97	+99	+99	+101	+101	+103	+105	+106	+105	+107	+109	+111	+112	+114	+115	+116	+117	+118	+119
50	+96	+91	+93	+94	+96	+97	+99	+99	+96	+97	+98	+98	+99	+100	+101	+102	+103	+102	+104	+106	+107	+106	+108	+110	+112	+113	+115	+115	+117	+118
51	+97	+92	+94	+95	+97	+98	+100	+100	+97	+98	+99	+99	+100	+101	+102	+103	+104	+106	+107	+108	+106	+109	+110	+110	+113	+114	+116	+116	+118	+118
52	+98	+93	+95	+96	+98	+99	+101	+101	+102	+99	+100	+100	+101	+102	+103	+105	+104	+107	+108	+109	+108	+110	+111	+113	+114	+116	+117	+119	+119	+119
53	+99	+94	+96	+97	+99	+100	+102	+																						

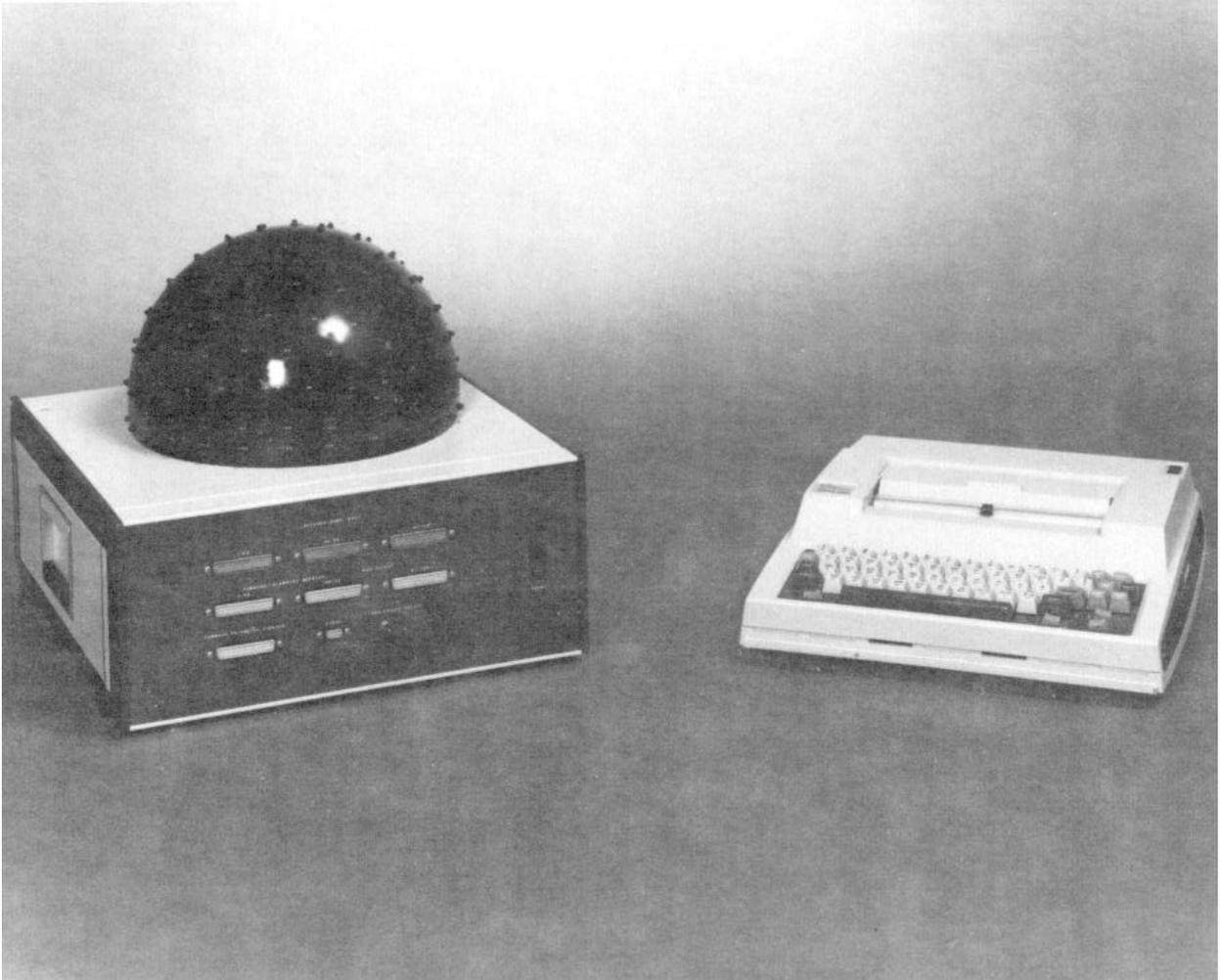


Figure 5. ESSA Test Controller