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INVESTIGATION OF THE STRESSES AND DEFLECTIONS INDUCED IN THE SUB-BASE AND BEARING SUPPORT OF A MEDICAL THERAPY UNIT

by

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PHYSICAL METALLURGY DIVISION

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SUMMARY OF RESULTS

Stresses induced at selected areas of a newly designed sub-base and bearing support, by the weight of the arm, head and counterweight assembly, as determined from electrical strain gauge readings, were less than 1600 psi tension and 1400 psi compression. Maximum static stress changes due to angular position of the arm were under 200 psi, and dynamic stresses induced by starting, stopping, and reversing arm rotation did not exceed 1200 psi. Maximum measured dynamic reflections were less than ±0.015 in. It may be noted that both stress and deflection maxima are approximately 50% of those measured on a fabricated arm support in 1963 (Mines Branch Investigation Report IR 63-114, November 26, 1963).

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INTRODUCTION

In a letter dated December 2, 1965, Mr. H. J. Barrett, of Equipment Production, Commercial Products Division, Atomic Energy of Canada, Ltd., South March, Ontario, requested a partial experimental stress analysis of a newly designed cast iron sub-base and bearing support for a Medical Therapy Unit. The investigation was to parallel that carried out on a fabricated support in 1963 and reported in Mines Branch Investigation Report IR 63-114, dated November 26, 1963, with the exception that stresses were to be determined at areas of the rear support member that were not covered in the earlier investigation.

METHOD OF TEST

Areas chosen for stress measurement were ground, thoroughly cleaned, etched and neutralized. Foil strain gauges, type EA-06-375BB-120, having a gauge length of 0.375 in. and a grid width of 0.263 in., were mounted at all positions with Eastman 910 cement and waterproofed with "Gaugecote" Type 1. Two temperature compensating gauges were similarly mounted on a nearby inoperative unit. All gauges were from the same lot, had the same gauge factor of 2.095 ± 0.5%, and were provided by Atomic Energy of Canada Ltd. Gauge positions are shown in Figure 1 and in the photographs, Figures 2, 3, 4 and 5. It may be noted (see Figure 5) that it was necessary to fold the tabs of gauges 17 and 18 over the edge of the sub-base because of the small clearance between the bolt heads and the edge. The entire grids of the gauges were, however, on the flat portion of the structure.

Since signal voltages from all gauges were expected to be very low, shielded cable (Belden No. 8424) was employed in order to minimize noise level. A single strand from each conductor was soldered to the gauge tabs.

The gauges were connected through two type SB1 switch and balance units to a type P350 strain indicator for static measurements, and to a Kelvin and Hughes Bridge-Amplifier and a two-channel recorder for dynamic measurements. A photograph of the complete set-up, with the arm, head and counterweight assembly removed, is shown in Figure 2. The arm, head and counterweight assembly are shown on a completed unit in Figure 6.

A cantilever, on which two foil strain gauges were mounted, was used in conjunction with the Kelvin and Hughes equipment to measure deflections at the positions and in the directions indicated by letters and arrows in Figure 1.

With the arm in the 0° position (vertical, with the head uppermost), all gauges were "zeroed" with the switch and balance units. Static strain readings were then taken with the arm at 90°, 180°, 270° and 0°, measured counter-clockwise when viewing the arm from the stretcher end of the unit.

Dynamic records were made as the arm was started and stopped (start-stop mode) at each of the angular positions noted above. Since a control unit was not connected to the machine, the arc mode was. simulated by starting rotation at 0°, and reversing rotation at 45°, 0°, 135°, 90°, 225°, 180°, 315° and 270°, in that order. Dynamic records were made during this operation, which was repeated a total of twelve times to include all gauges. Angular velocity of the arm was approximately 1 rpm. After each operation, static readings were taken at the 0° position to check "zero drift".

Deflection records were made using both the start-stop and simulated arc modes, as above, for each of the nine positions indicated in Figure 1, and "zero drift" was again checked.

The arm, head, and counterweight assembly were removed, and static readings were taken on all gauges, thus providing a measure of stresses induced by the weight of the assembly.

RESULTS OF TEST

Strain gauge readings and recordings were converted to strain, and thence to stress values, using 16×10^6 psi as the modulus of elasticity for the material, stated to be Class 30 grey iron. The fatigue limit in reversed bending was stated to be ±14,000 psi. Stresses are, of course, averaged over the grid area of the gauges (0.375 in. x 0.263 in.).

Static stresses, along with maximum "zero" variations are listed in Table 1, peak dynamic stresses and frequencies of stress variations in Table 2, and deflections with their frequencies in Table 3.

Dynamic stresses were, in general, highest on the simulated arc mode, and all dynamic stresses were very highly damped. In many cases, a single stress impulse was recorded, and in many more the amplitude was so low that frequencies could not be determined.

DISCUSSION OF RESULTS

From Table 1, it is apparent that static stresses induced by the weight of the arm, head, and counterweight assembly are very low, and that stresses induced by rotation are insignificant. Zero drift was well within the accepted tolerance, indicating that all gauges were performing satisfactorily. The signs and relative magnitudes of the stresses are as one would predict, with the exception of those from gauges 1 and 14, whose magnitudes are of the order generally accepted for "zero-drift". Areas near the hold-down bolt holes (Gauges 13 to 20) were considered to be critical, but both radial and tangential stresses were extremely low.

TABLE 1

Static Stresses in psi

(Tension + ve)

Gauge No.	Stress Variation from 0°			Stress Induced by Head, Arm, and Counterweight	Maximum "Zero" Variation
	90°	180°	270°		
1	0	-65	0	-430	0
2	0	0	0	-240	80
3	-100	-80	+20	+1330	80
4	-50	-50	0	+200	110
5	0	0	+110	-430	100
6	0	0	0	+230	65
7	0	0	0	-1280	55
8	0	0	0	+420	80
9	0	+70	+100	+160	80
10	0	+60	0	+400	30
11	0	0	0	+1260	65
12	0	0	0	+820	30
13	0	0	0	-110	80
14	0	0	0	-110	65
15	0	0	0	-580	80
16	0	0	0	-210	50
17	0	0	0	+400	80
18	0	0	0	+610	100
19	0	0	-50	0	65
20	0	0	-50	+1120	155
21	0	0	-20	-240	35
22	-40	-20	-20	+1460	65

TABLE 2

Maximum Peak Dynamic Stresses in psi, ±;

Frequencies in cps

0 = Transient - very highly damped
X = Very low amplitude - frequency indeterminate

Gauge No.	Start-Stop Mode				Simulated Arc Mode								Freq.
	0°	90°	180°	270°	45°	0°	135°	90°	225°	180°	315°	270°	
1	170	120	120	170	270	230	390	270	230	160	230	270	0
2	690	620	690	770	420	1000	460	770	620	770	620	770	3.0
3	460	460	540	460	390	620	540	540	460	620	230	540	2.6
4	80	40	40	0	80	80	40	40	80	40	120	0	2.6
5	80	80	80	80	120	40	120	40	120	40	120	40	2.5
6	40	40	40	40	40	40	40	80	40	40	40	40	X
7	80	80	120	80	80	80	80	80	80	80	40	80	3
8	50	0	0	0	0	0	0	0	0	0	0	0	X
9	0	0	0	0	0	0	0	0	0	0	0	0	X
10	90	90	130	130	130	130	90	130	90	170	90	170	3.0
11	200	200	250	200	200	250	290	150	200	250	200	200	3.0
12	220	330	330	220	240	220	240	330	440	440	330	330	3.0
13	0	0	110	0	0	0	0	0	0	0	0	0	0
14	110	60	60	110	0	60	0	110	0	60	0	170	3.0
15	0	110	170	110	110	60	170	60	170	170	170	110	0
16	0	0	0	0	0	0	0	0	60	0	60	0	X
17	0	0	60	60	0	0	0	60	0	60	0	0	X
18	120	120	120	120	180	180	120	120	120	120	60	120	3.0
19	220	220	220	110	110	220	220	170	220	110	220	110	3.0
20	300	360	360	300	300	180	480	180	300	240	420	180	3.1
21	0	0	0	0	0	0	0	0	0	0	0	0	X
22	0	40	40	40	80	0	0	80	0	0	0	80	3

TABLE 3
Deflections in in. x 10^3 ±;

Frequencies in cps

Pos'n	Start-Stop Mode				Simulated Arc Mode								Freq.
	0°	90°	180°	270°	45°	0°	135°	90°	225°	180°	315°	270°	
A	2	6	2.5	3	5	2	3	3	2.5	2	3	3	3.3
B	3	4	4	4	5	4	3	3	4	3	3	4	3.0
C	5.5	8.5	10	8	8.5	7	8.5	7	9	8	8.5	7	3.0
D	3	8	3	6	7	3	6	7	5	3	6	6	3.0
E	3	8	3	7	8	4	4	11	9	3	7	9	3.0
F	1	2	1	2	2	1	1	2	1	1	1	2	3.0
G	1	2	1	2	1	1	2	3	1	1	1	2.5	3.0
H	1	2	1	2	2	1	2	2	1	1	1	3	3.0
K	1	2	2.5	2	2	2.5	2	4	2	3	2.5	3	3.0

Dynamic stresses and deflections, as seen from Tables 2 and 3 were insignificantly low.

CONCLUSION

Measurement of static and dynamic strains at selected areas of a cast sub-base and bearing support for a Medical Therapy Unit indicated that total maximum stresses are very low, not exceeding about 2500 psi. Deflections at selected areas of the assembly during operation do not exceed about ± 0.015 in.

ACKNOWLEDGEMENT

The staff of Atomic Energy of Canada Ltd. carried out all the necessary heavy work, provided many conveniences for carrying out the investigation, and assisted in numerous small tasks. The assistance rendered is acknowledged with gratitude.

FWM/KAR/KW
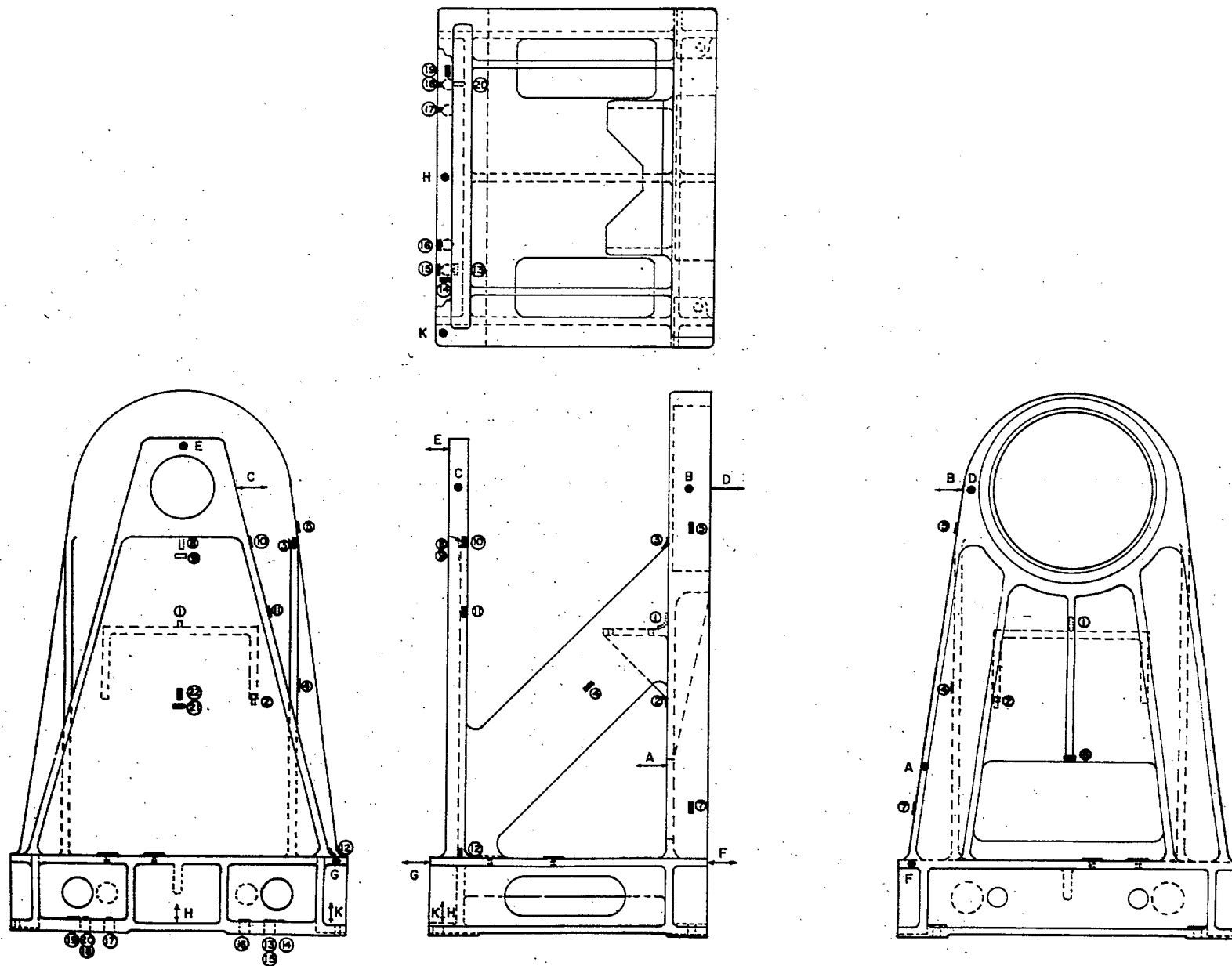
Figure 1. Location of Strain Gauges (numbers) and Deflections (letters and arrows).
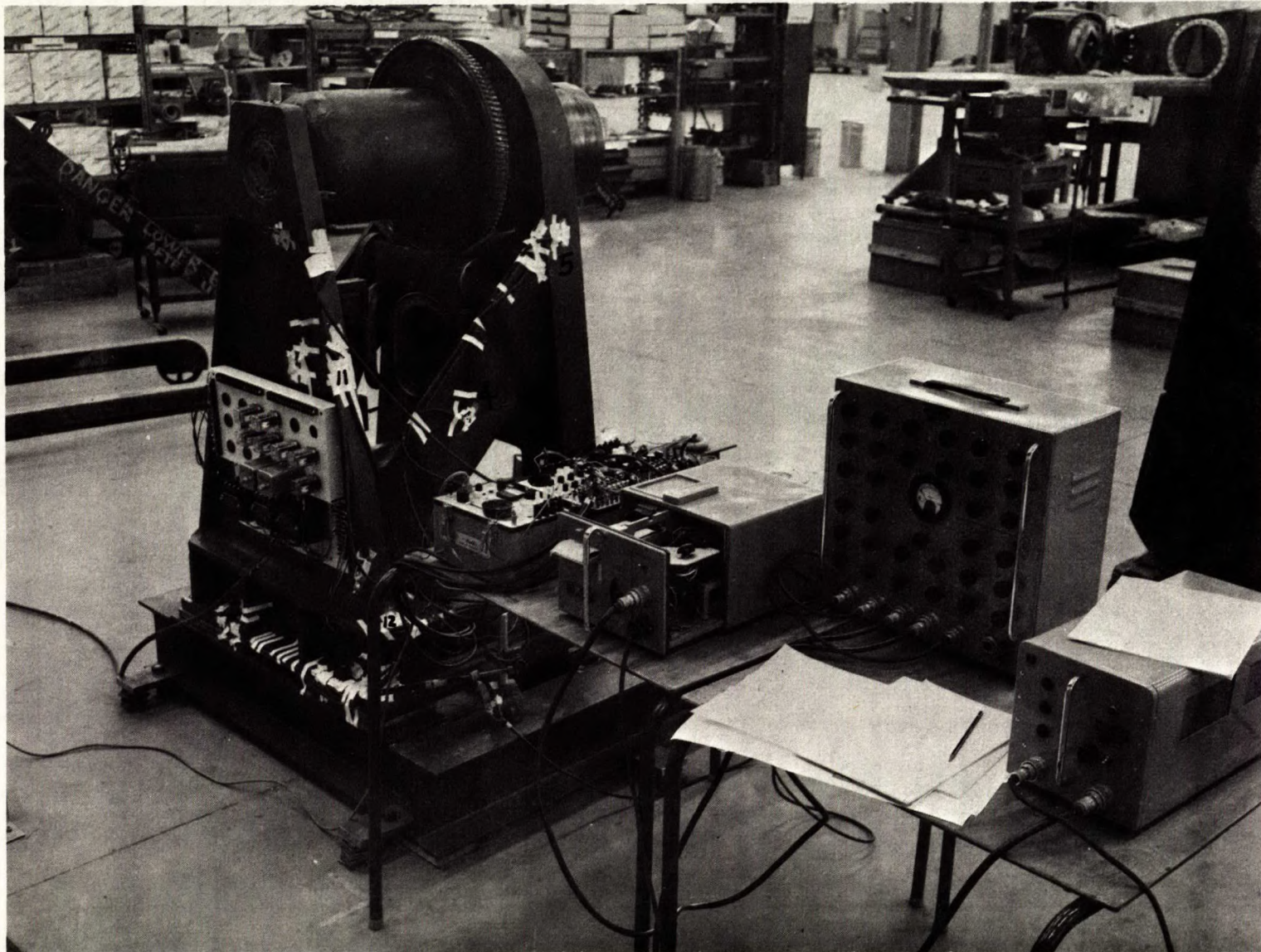
Figure 2.   View of Sub-Base and Bearing Support with Strain Gauge
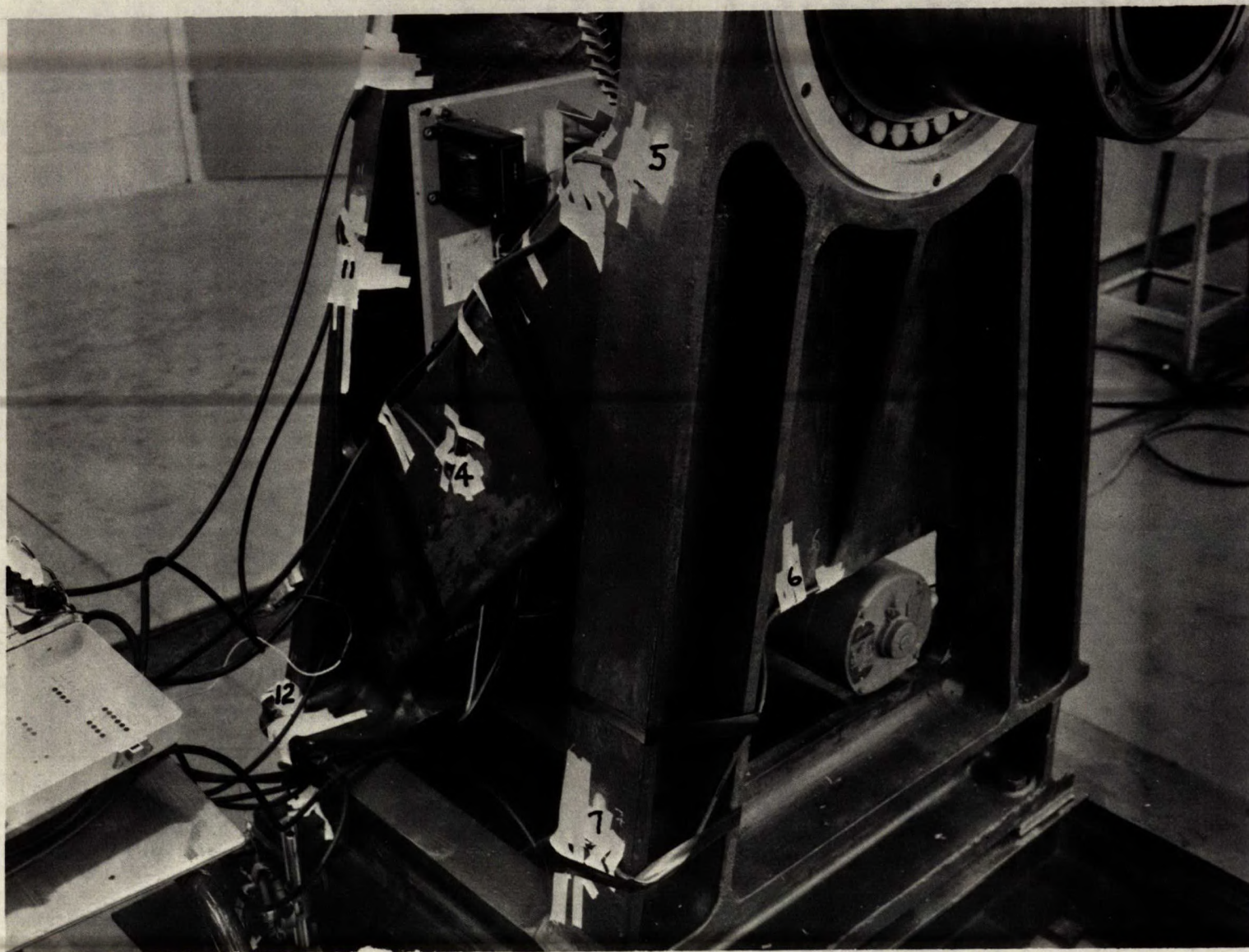Equipment.

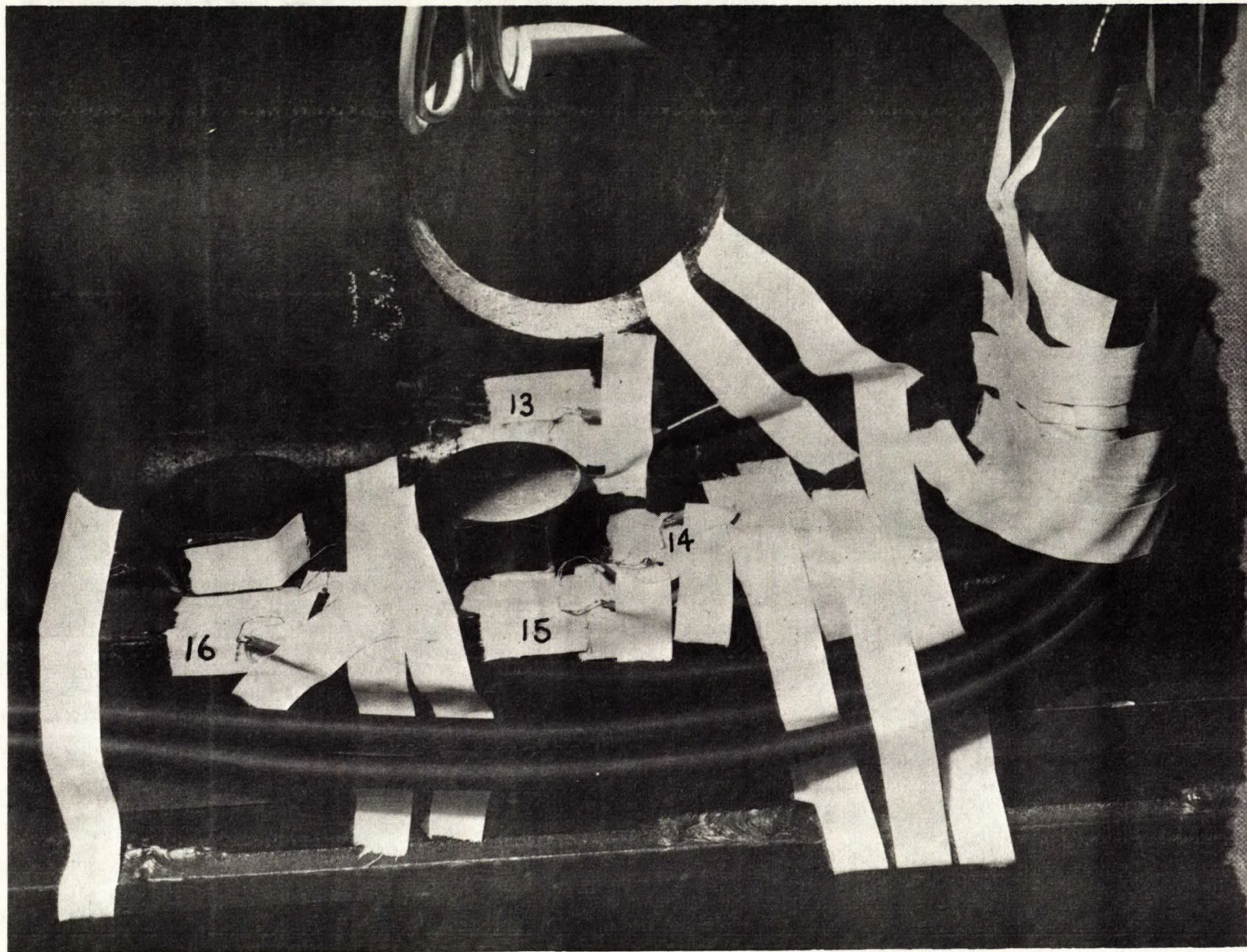Figure 3. Close-up of gauges on Bearing Support.

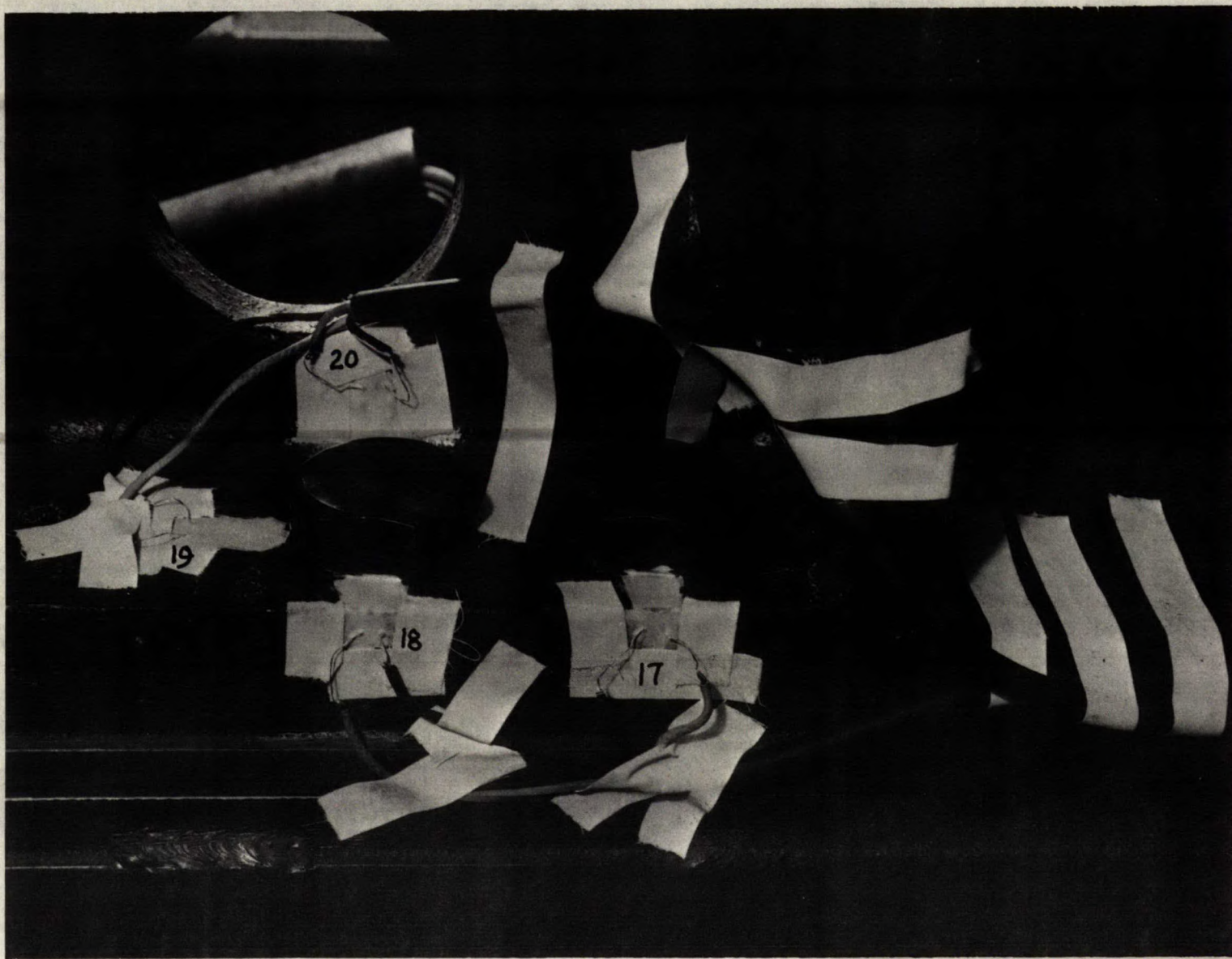Figure 4.   Close-up of Tangential Gauges Near Bolt-Holes
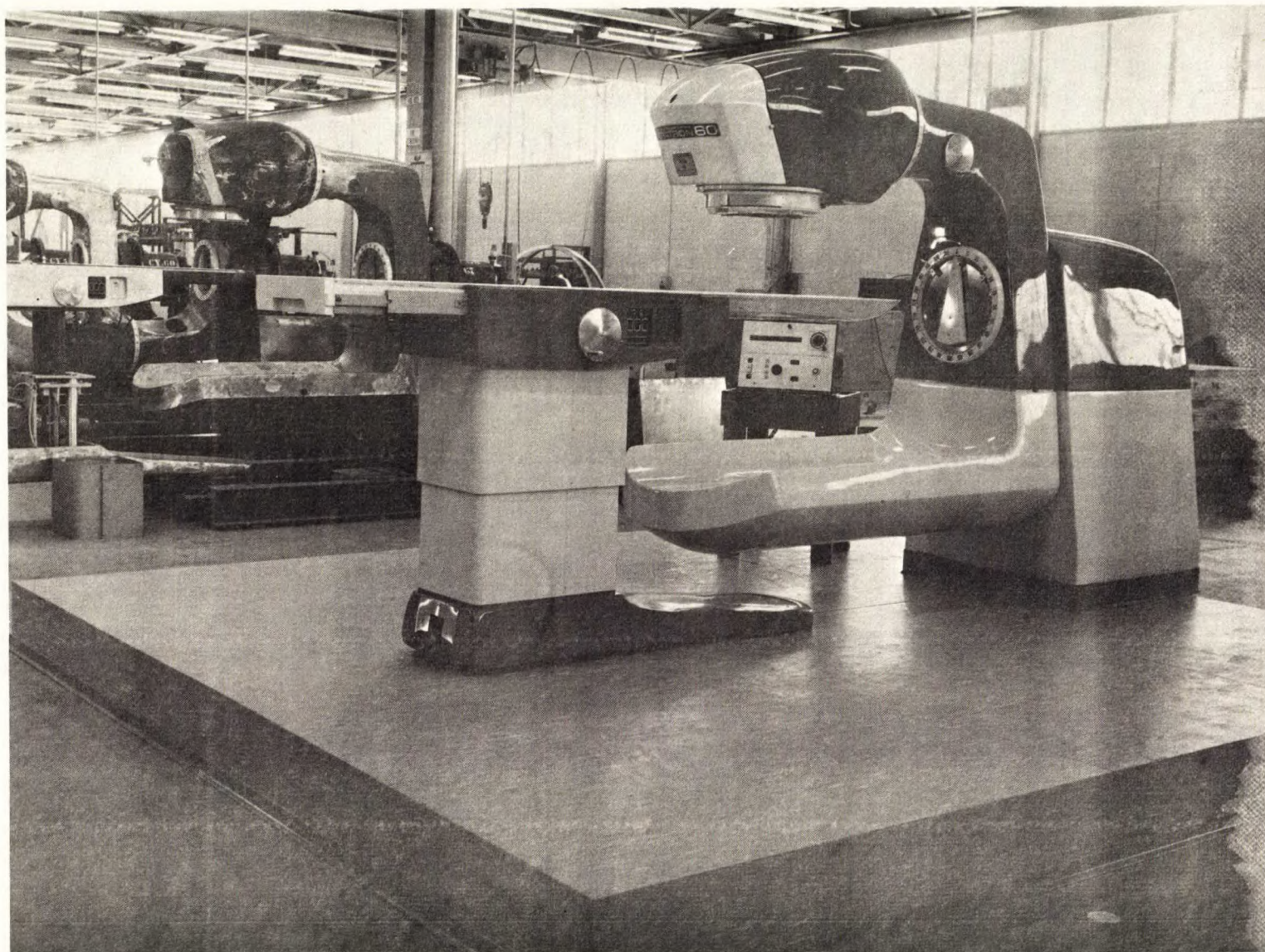
Figure 5.   Close-up of Radial Gauges Near Bolt-Holes.

Figure 6.   View of Completed Medical Therapy Unit.