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RB Crasser
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W Layne Redassify
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CENTRAL TECHNICAL FILE
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DYNAMIC CRUSH TEST OF PAPER HONEYCOMB (U)

Organization 7300 Environmental Test Report

I. K. Petersen, Org. 7341

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DYNAMIC CRUSH TEST OF PAPER HONEYCOMB (U)

Introduction

The object of this test was to provide information on the characteristics of four basic types of paper honeycomb when dynamically loaded to failure in compression. Samples of the different types were to be tested with the load being applied along the axis of the cells in the bulk of the tests. The test data would be used as a basis for establishing dynamic crush strength values of the material for design information purposes.

The initial test program called for a test group of 30 blocks of honeycomb. This was to be increased to 70 samples if the program appeared to be producing satisfactory results. There was also the possibility of an additional group of 30 blocks which would be tested to a different acceleration-time input. Most of the blocks were to be tested to an input pulse having a constant slope rise time of 3.5 to 4 ms to 150g, dwell at 150g for 10 to 12 ms, with a total velocity change of approximately 71 fps. The testing was scheduled to be done on DT-1, which is a 14-foot accelerated shock machine. The special test fixture would be supplied by the requester.

Four channels of instrumentation were required to provide the desired test data. Two channels were to be for acceleration, one channel was to be for displacement measurement of the honeycomb crush and the last channel was to monitor impact velocity of the machine carriage. In addition to this, Fastax camera coverage of 5 or 6 tests would be required.

The test was requested by J. L. Irwin, 5632, on March 6, 1964. Initial tests were done in October of 1964, with the test program completed in December of 1965.

Summary

This test was conducted to provide data on the dynamic crush characteristics of different types of paper honeycomb. A total of 58 blocks of four basic types were crushed. In all cases, a shaped acceleration-time input load to the block was used with impact velocities ranging from 16 to 64 fps. Data obtained during the tests included the acceleration levels required to obtain honeycomb crush, and the compression of the particular sample during loading and failure. From these values, the load carrying capability of particular types of honeycomb under certain conditions could be determined. Peak loadings at failure ranged

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from less than 1g to 175g, depending on the type being tested, with corresponding compressive displacements of .020 inches to .148 inches. In general, the test data obtained was satisfactory.

Procedure

An initial group of 37 honeycomb samples and the test fixture were prepared by the requester for the first test series. The group of samples consisted of 34 short curved blocks and three long curved blocks. Typical examples of these blocks can be seen in Figures 1 and 2 respectively. The fixture consisted basically of a lightweight rectangular-shaped frame, which mounted directly on the table of DT-1. A large steel block (243 pounds) was free to move in guides which were installed in opposite sides of the frame. During the test, a honeycomb sample was placed in the fixture so that it was underneath the mass and resting on the fixture base. This test arrangement, with the sample in place, can be seen in Figure 3.

The transducers used in the test can be seen in Figures 3 and 4. At least two accelerometers were used, one on the fixture base and one on the movable mass. Third and fourth accelerometers were frequently used throughout the test as backups to the required accelerometers, and also to provide additional information. The output of the accelerometers was monitored by means of a standard Microdot cable-cathode follower arrangement. The only exception to this was a Statham accelerometer used on a few tests, which utilized a strain gage type of instrumentation system. The displacement transducer can be seen mounted in the top cross member of the fixture frame. Special instrumentation was required for this variable reluctance transducer, and also, a special fixture had to be fabricated so that it could be properly balanced and calibrated. The breaker unit of the velocity indicator is shown mounted on the carriage with the light beam-photocell combination attached to a stand external to the machine. All test data were recorded on magnetic tape. A description of all instrumentation used in the test can be found in Table I.

The test procedure generally used in the program is outlined as follows:

1. The correct aluminum honeycomb impact block was selected. These consisted of from 1 to 9 separate pieces which were designed to provide a particular input to the test fixture. The tops of these honeycomb blocks were shaped to provide the desired rise time. A block assembly can be seen in place on the anvil of DT-1 in Figure 3.

2. The fixture was prepared by first loosening the mass retaining screws. The mass was then raised slightly and the test block was placed on the fixture anvil. The mass retaining screws were then positioned so that the retainers were snug against the top of the steel block. This prevented the mass and specimen from moving away from the anvil during acceleration after carriage release.

3. The displacement transducer probe was positioned so that it was at the zero position.

4. The test was run by raising the entire carriage and fixture to a predetermined drop height. This was done so that the correct impact velocity would be obtained. The carriage was then released and allowed to impact. The carriage crushed the aluminum honeycomb thus providing the input to the fixture and then came to rest. The steel block in the fixture crushed the paper honeycomb for a short distance and was stopped by the lead plates located underneath it. The test setup immediately after completion of a test can be seen in Figure 5. A typical test record (Test 43) can be seen in Figure 6.

During the course of the test program, many changes were made to the general test setup to facilitate testing and to prevent damage to the transducers and the fixture. Among these were addition of lead plates to stop the steel mass, changed types of displacement transducers and accelerometers, and changes in transducer mounting locations and methods. Figures 3 through 5 show the configuration, which was finally developed as the most efficient and durable.

An additional group of test samples was prepared by the requester to augment the initial group. At the conclusion of the test program, a total of 68 tests had been completed, which resulted in the crushing of 58 test samples.

Results

A complete tabulation of pertinent test data can be found in Table II. The data of particular interest are the peak acceleration load seen by the mass as it compresses the honeycomb sample and the displacement of the mass during this loading phase. Since the weight of the steel mass is known to be 243 pounds, the load-carrying capacity of a particular sample can be determined. The displacement vs time data will provide information on the energy-absorbing capabilities of the material.

In general, the results appear to be reasonable; however, it is not possible to fully evaluate them without more knowledge of the test specimens such as density and cross-sectional area. The test samples can be divided into four general types, and the results will be discussed from that standpoint.

In the case of the long curved blocks (LC) (Figure 2), the results do not appear consistent. The first three samples tested (Tests 1-3) all failed when acceleration levels reached approximately 120g. The

balance of these samples failed when the mass acceleration reached values in the range of 140g to 150g. The reason for the differences in loading at failure is not certain unless the samples were of different densities or dimensions. The displacement values of the mass at failure ranged from .100 to .148 inch, which seems reasonable.

The mass acceleration amplitude for the short curved samples (S.C.) (Figure 1), ranged from 125g to 175g with an average value of about 149g. The mass displacement at failure was not as consistent for this group, since it ranged from .058 inch to .140 inch with an average value of approximately .98 inch.

The third general group of test blocks to be considered are the chevron and dovetail samples (Tests 49 through 56). This group is divided into three sub-groups consisting of the seven-pound chevron, six-pound dovetail, and eight-pound dovetail. The results were somewhat different depending on the type of block tested, but in general appeared to be reasonable.

The fourth and last group of test blocks were very unusual (Tests 57 through 66). These were designed to be tested so that the load was applied along an axis which was nearly normal to the axes of the cells. It was correctly estimated that they would be very weak in this direction. This group was also divided into sub-groups, seven-pound and eight-pound horizontal and seven-pound and eight-pound vertical. The peak mass acceleration values were quite erratic. The seven-pound horizontal samples (2 each) provided values of 1.3g and 2.6g. The eight-pound vertical samples (3 each) varied from .8g to 2.8g. The displacement values at failure are not nearly as inconsistent, ranging from .038 inch to .068 inch for the eight-pound vertical blocks. It is interesting to note that the lowest acceleration amplitude at failure corresponded to the greatest displacement for this particular sub-group (Test 59).

A Statham accelerometer was mounted on the mass for about half of this last group of tests. The reason for this is that it is very difficult to accurately measure such low amplitudes with a piezoelectric accelerometer on a boosted machine. A correction factor was then determined and used to adjust the balance of the acceleration values. If more tests are done with this very soft material, it is recommended that other instrumentation possibilities be investigated to provide more confidence in the validity of these low acceleration values.

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It is worthwhile to consider the different types of sample failure observed during the test. The curved blocks generally failed in compression alone or experienced column failure alone. Typical examples of each type of failure for the long curved and short curved blocks can be seen in Figures 7 through 10. The flat blocks sometimes failed in pure compression (Figure 11), but generally experienced a combined compression and column failure (Figures 12 through 14). The very weak honeycomb samples always failed in column. Figure 15 shows a typical example of this type of block and mode of failure.

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TABLE I

INSTRUMENTATION

ACCELEROMETERS:

Endevco, Model 2213C, Ser. Nos. GR08, JC77, GR23, GR90, 8406, 1736, JC22

Model 2225M1, Ser. No. HA27

Model 2221M1, Ser. No. FA10

Clevite, Model 5CW1, Ser. Nos. 2663, 2667

Statham, Model A5A-25-335, Ser. No. 3316

DISPLACEMENT TRANSDUCERS:

Crescent, Models KB400, KB200

PREAMP POWER SUPPLY:

Tektronix, Type 127, S-162882

PLUG-IN-UNIT:

Tektronix, Type Q, S-137050

AMPLIFIER:

Alleghany, Model 516-A1, DC, S-144887

OSCILLOSCOPE:

Tektronix, Model 502, S-113742

TAPE RECORDER:

CEC, Model XR-2600, S-134838

CONSOLE:

Standard Shock Lab Type, No. 8

CATHODE FOLLOWER:

Modified Shock Lab Type, Multi-channel

EMITTER FOLLOWER:

Area III Type, 2 channel

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TABLE II

TEST DATA

Test No.	Sample No.	Impact Velocity ft/sec	Conditions At Beginning of Crush or Maximum Compression of Paper Honeycomb				Comments
			Carriage Acceleration		Mass		
			g's	Rise Time ms	Acceleration g's	Displacement inches	
1	120-8#-D2-Ring 1, LC	37.9	94	4.30	121	.128	
2	120-8#-D1-Ring 3, LC	40.0	103	4.30	117	.075	Displacement record doubtful.
3	120-8#-D1-Ring 1, LC	35.7	125	6.20	118	----	Bad displacement record.
4	1577-D3-D-2, SC	34.9	53	5.20	-----	.054	No crush; bad mass acceleration record; 210 cps mass oscillation.
5	1577-D3-D-3, SC	34.7	90	4.30	60	.076	No crush; 210 cps mass oscillation.
6	1581-D3-D-3, SC	38.0	107	4.20	75	.077	No crush; 210 cps mass oscillation.
7	1579-D-4, SC	45.5	150	4.00	71	.065	No crush; 210 cps mass oscillation.
8	1582-D3-D-2, SC	63.7	160	3.50	175	.104	

LC = Long Curved SC = Short Curved

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TABLE II

TEST DATA

Test No.	Sample No.	Impact Velocity Ft/sec	Conditions At Beginning of Crush or Maximum Compression of Paper Honeycomb				Comments
			Carriage Acceleration		Mass		
			g's	Rise Time ms	Acceleration g's	Displacement inches	
9	1576-D-2, SC	46.8	108	3.70	145	----	Bad displacement record; no crush.
10	1594-D-4, SC	46.9	95	4.10	160	----	Bad displacement record.
11	1582-D3-D-1, SC	47.2	88	3.60	148	.100	
12	1577-D3-D-1, SC	54.8	87	3.60	145	.105	
13	1574-D-1, SC	47.2	102	4.00	147	.105	Fastax
14	1594-D-2, SC	45.2	80	4.20	150	.115	Fastax
15	1582-D3-S-2, SC	51.2	108	3.65	146	.105	Fastax
16	1583-D-2, SC	56.2	90	3.75	153	.105	Fastax
17	1578-D-1, SC	50.8	-----	4.10	158	.100	Bad record from carriage accelerometer.
18	1580-D-3, SC	49.6	-----	4.80	160	.100	Bad record from carriage accelerometer.

LC = Long Curved SC = Short Curved

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TABLE II

TEST DATA

Test No.	Sample No.	Impact Velocity ft/sec	Conditions At Beginning of Crush or Maximum Compression of Paper Honeycomb				Comments
			Carriage Acceleration		Mass		
			g's	Rise Time ms	Acceleration g's	Displacement inches	
19	1578, D-1, SC	48.4	155	4.60	142	.088	
20	1579-D-1, SC	50.8	138	5.40	143	.075	
21	1578-D-3, SC	50.2	107	4.20	153	.083	
22	1581-D-3, SC	50.8	153	4.40	157	----	Bad displacement record.
23	1594-D-3, SC	52.7	130	4.10	151	.095	
24	1594-D-1, SC	52.7	148	4.70	152	----	Bad displacement record.
25	1578-D-2, SC	51.8	120	4.30	162	.103	
26	1574-D-2, SC	52.7	148	4.70	125	.070	
27	1583-D-1, SC	52.1	200	5.60	148	.058	
28	1581-D3, D-2, SC	51.8	170	5.00	147	.103	
29	1576-D-1, SC	50.5	170	5.90	140	.095	

LC = Long Curved SC = Short Curved

TABLE II

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TEST DATA

Test No.	Sample No.	Impact Velocity ft/sec	Conditions At Beginning of Crush or Maximum Compression of Paper Honeycomb: Carriage Acceleration g's	Carriage Acceleration Rise Time ms	Mass Acceleration g's	Mass Displacement inches	Comments
30	1582-D-3, SC	50.2	175	5.40	147	.088	
31	1580-D-1, SC	51.7	180	5.40	151	.080	
32	1579-D-2, SC	52.1	120	3.70	152	.140	
33	1574-D-3, SC	51.4	145	4.10	143	.105	
34	1577-D3-D-2, SC	52.1	155	4.20	150	.125	
35	1577-D3-D-3, SC	52.1	160	3.90	140	.120	
36	1581-D3-D-3, SC	49.5	98	3.90	130	.070	Failure over approximately 25% of the surface.
37	120-8-R3-D-2, LC	46.1	55	4.90	107	.080	No crush.
38	120-8-R3-D-2, LC	49.8	85	4.70	150	.135	
39	120-8#, Ring 1, D-1, LC	42.4	88	5.30	121	.087	No crush.
40	120-8#, Ring 1, D-1	46.3	92	5.10	150	.148	

LC = Long Curved SC = Short Curved

TABLE II

TEST DATA

Test No.	Sample No.	Impact Velocity ft/sec	Conditions At Beginning of Crush or Maximum Compression of Paper Honeycomb: Carriage Acceleration g's	Carriage Acceleration Rise Time ms	Mass Acceleration g's	Mass Displacement inches	Comments
41	120-8½, Ring 2, D-2, LC	46.5	104	5.20	132	.085	No crush.
42	120-8½, Ring 2, D-2	46.1	121	5.30	148	.097	Block showed slight signs of yielding.
43	7-7-D1, LC	45.7	122	4.60	148	.120	
44	8-7-D2, LC	46.3	124	5.50	140	.115	
45	8-7-D1, LC	45.7	117	4.60	140	.108	
46	4-7-D1, LC	45.9	75	5.20	140	.100	No crush
47	5-7-D1, LC	49.0	120	4.40	138	.100	
48	6-7-D1, LC	50.0	138	5.10	140	----	No displacement record.
49	B-77, 7 lb. CHEVRON	50.5	100	3.70	65	.075	
50	B-96, 8 lb. DOVETAIL	48.3	132	4.30	90	.095	

LC = Long Curved SC = Short Curved

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TABLE II

TEST DATA

Test No.	Sample No.	Impact Velocity ft/sec	Conditions At Beginning of Crush or Maximum Compression of Paper Honeycomb				Comments
			Carriage Acceleration		Mass		
			g's	Rise Time ms	Acceleration g's	Displacement inches	
51	B-95, 8 lb. DOVETAIL	47.4	90	4.70	90	.108	
52	B-92, 6 lb. DOVETAIL	45.0	102	4.90	62	.100	
53	B-93, 6 lb. DOVETAIL	46.9	108	4.60	62	.102	
54	B-94, 6 lb. DOVETAIL	46.1	98	4.50	60	.122	
55	B-70, 7 lb. CHEVRON	46.3	90	4.40	68	.063	
56	B-97, 8 lb. DOVETAIL	46.1	110	4.80	80	.080	
57	B-40, 7 lb., HOR.	20.6	10.5	7.20	1.3	.020	
58	B-54, 8 lb., HOR.	17.0	6.8	8.20	2.3	.020	
59	B-58, 8 lb., VERT.	16.9	10.8	12.00	.8	.068	

LC = Long Curved SC = Short Curved

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TABLE II

TEST DATA

Test No.	Sample No.	Impact Velocity ft/sec	Conditions At Beginning of Crush or Maximum Compression of Paper Honeycomb				Comments
			Carriage Acceleration		Mass		
			g's	Rise Time ms	Acceleration g's	Displacement inches	
60	B-46, 7 lb., VERT.	16.3	13.8	12.00	.5	.075	
61	B-48, 7 lb., VERT.	17.2	12.0	9.70	.6	----	No displacement record.
62	B-42, 7 lb., HOR.	17.0	7.0	8.10	2.5	----	No displacement record.
63	B-60, 8 lb., VERT.	17.0	10.6	10.30	1.2	.038	
64	B-59, 8 lb., VERT.	17.1	10.0	10.20	2.8	.041	
65	B-52, 8 lb., HOR.	17.0	8.0	8.00	1.3	.025	
66	B-41, 7 lb., HOR.	16.8	6.8	7.60	1.0	.020	
67	4-7-D2, LC	46.5	83.0	4.80	132.0	.092	No crush
68	4-7-D2	50.5	109.0	4.00	145.0	.125	
	B-47 and B-53						Collapsed in fixture while moving the machine carriage therefore could not be tested.

LC = Long Curved SC = Short Curved

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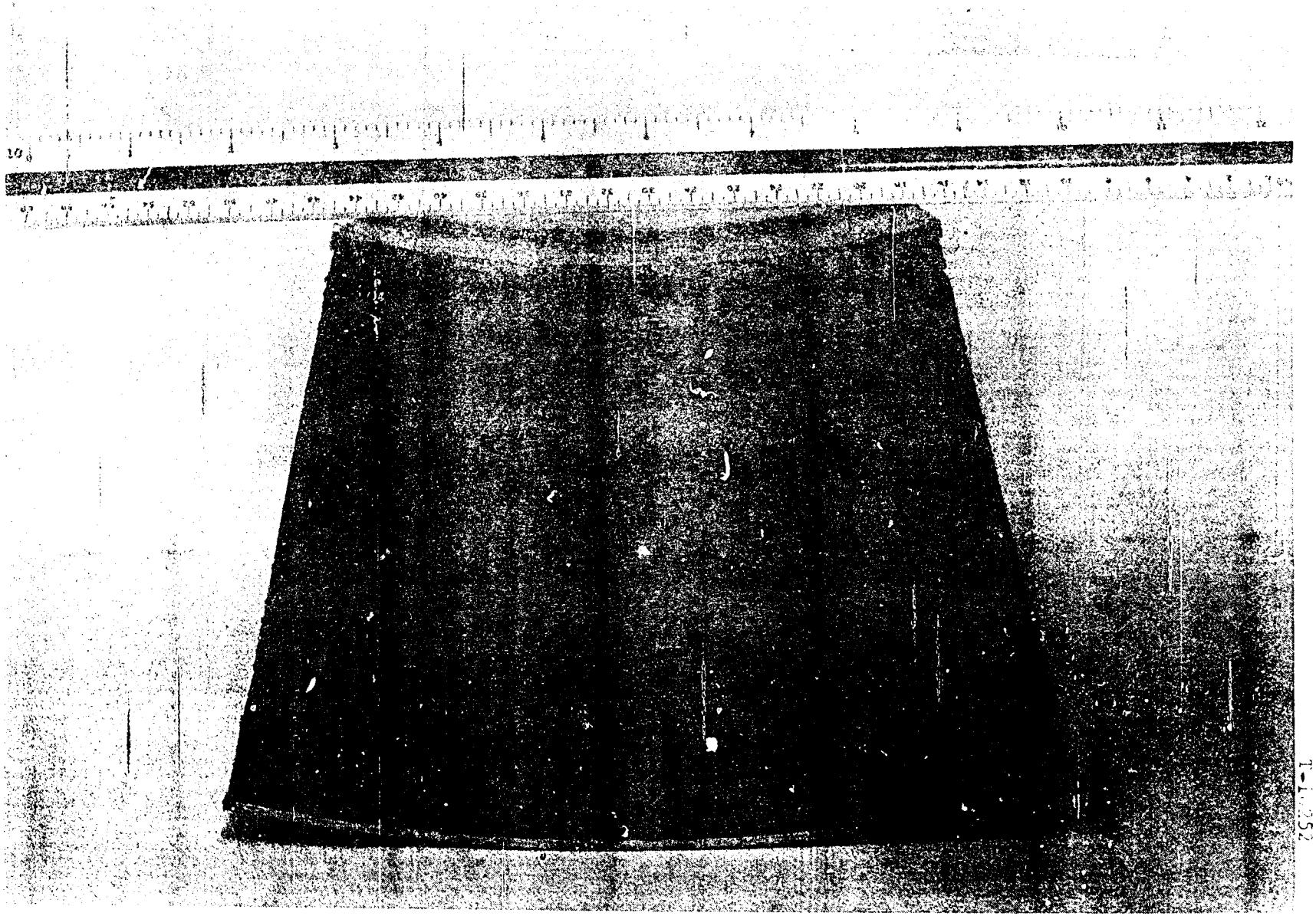

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FIGURE 1. SHORT CURVED SPECIMEN.

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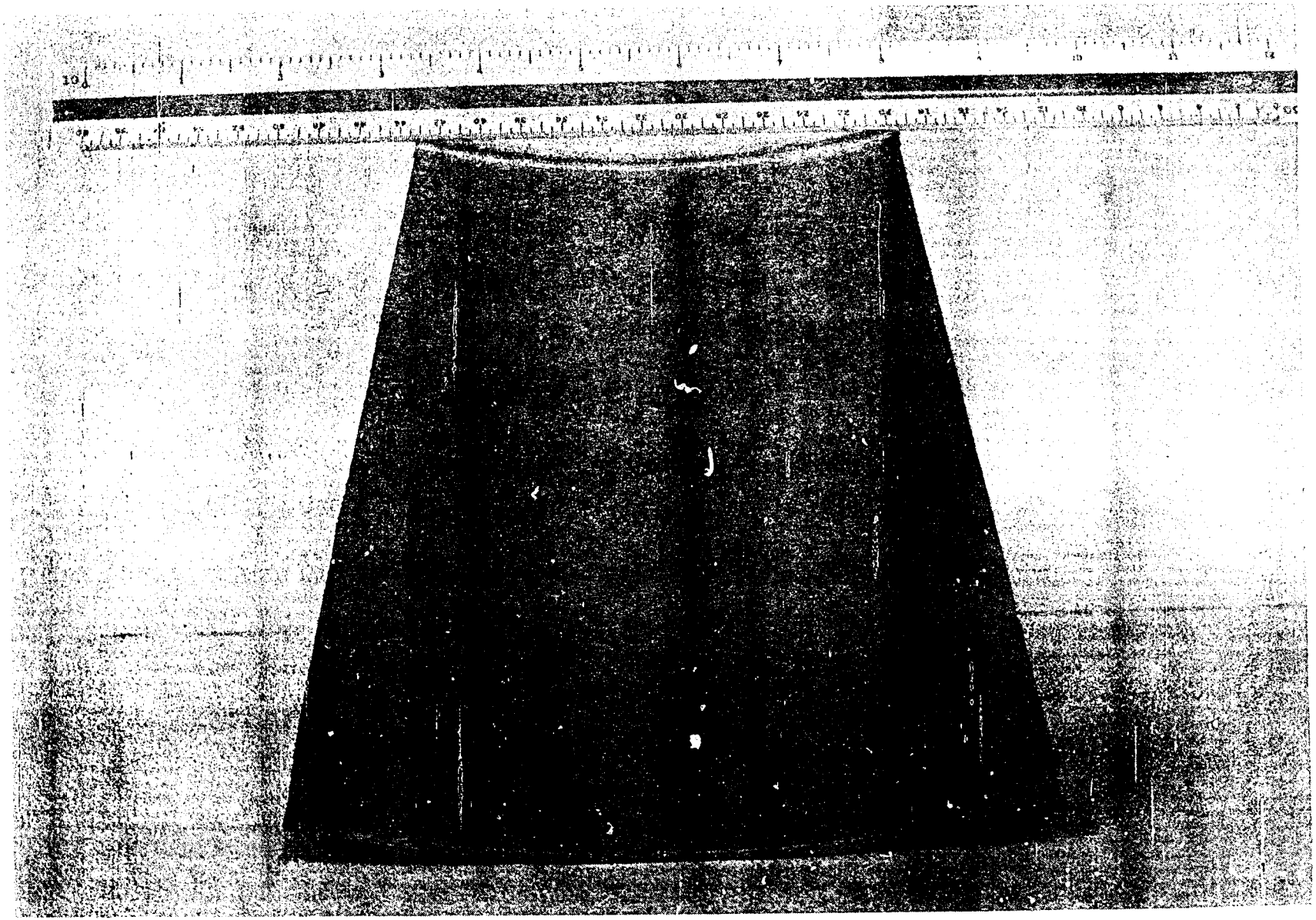

FIGURE 2. LONG CURVED SPECIMEN.

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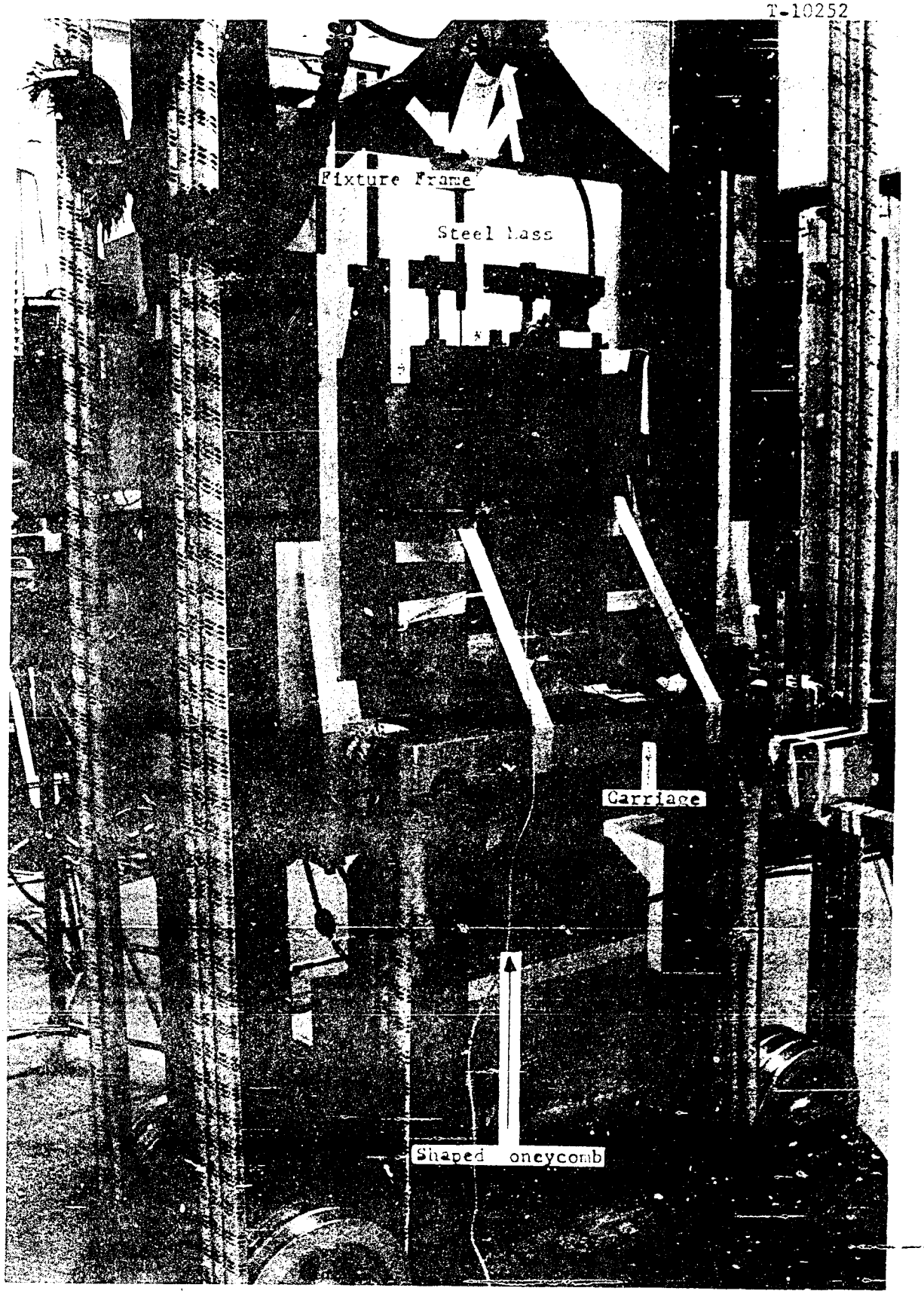

FIGURE 3. TEST SETUP BEFORE DROP.

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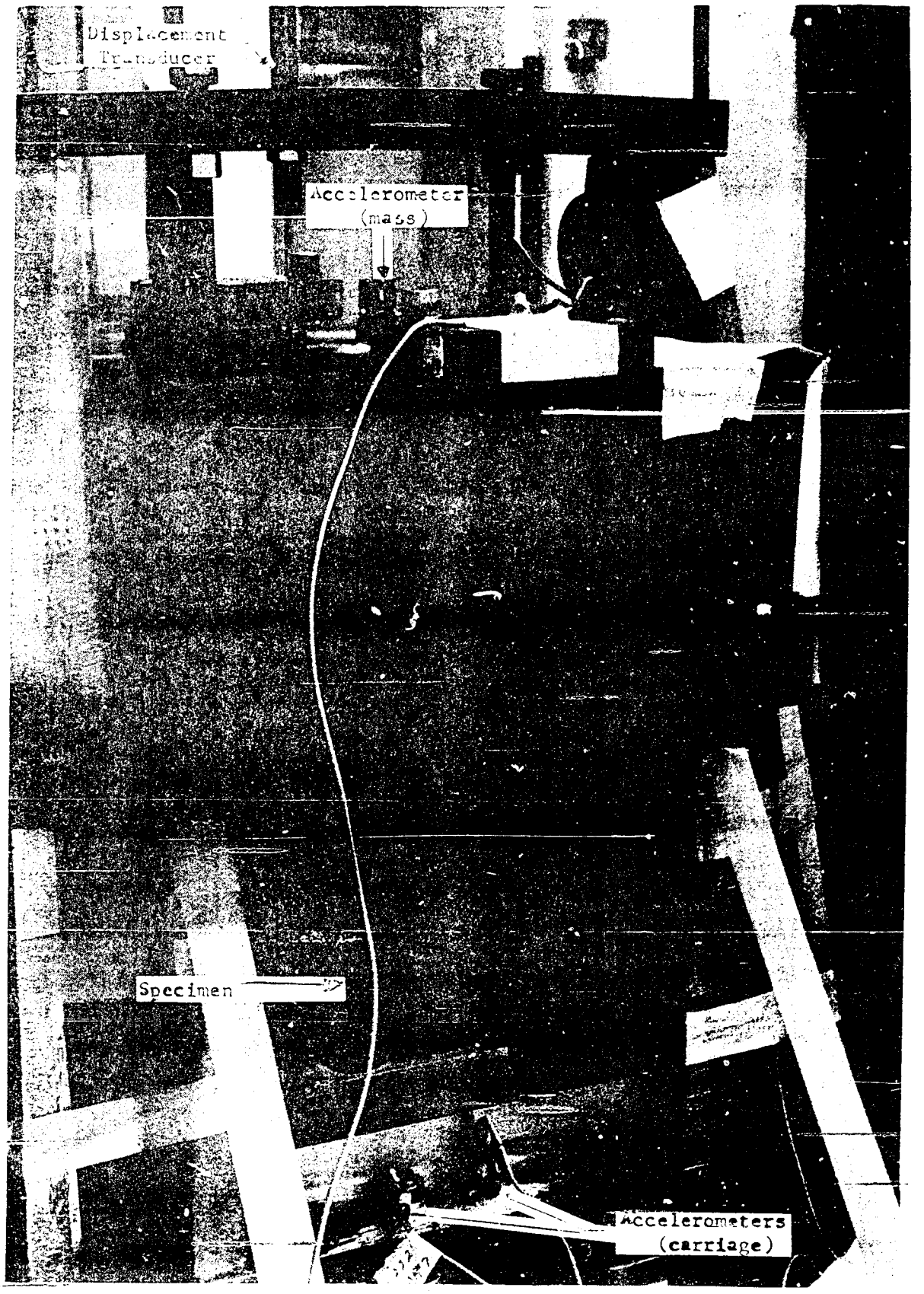

FIGURE 4. TEST SETUP

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FIGURE 5. TEST SETUP AFTER DROP.

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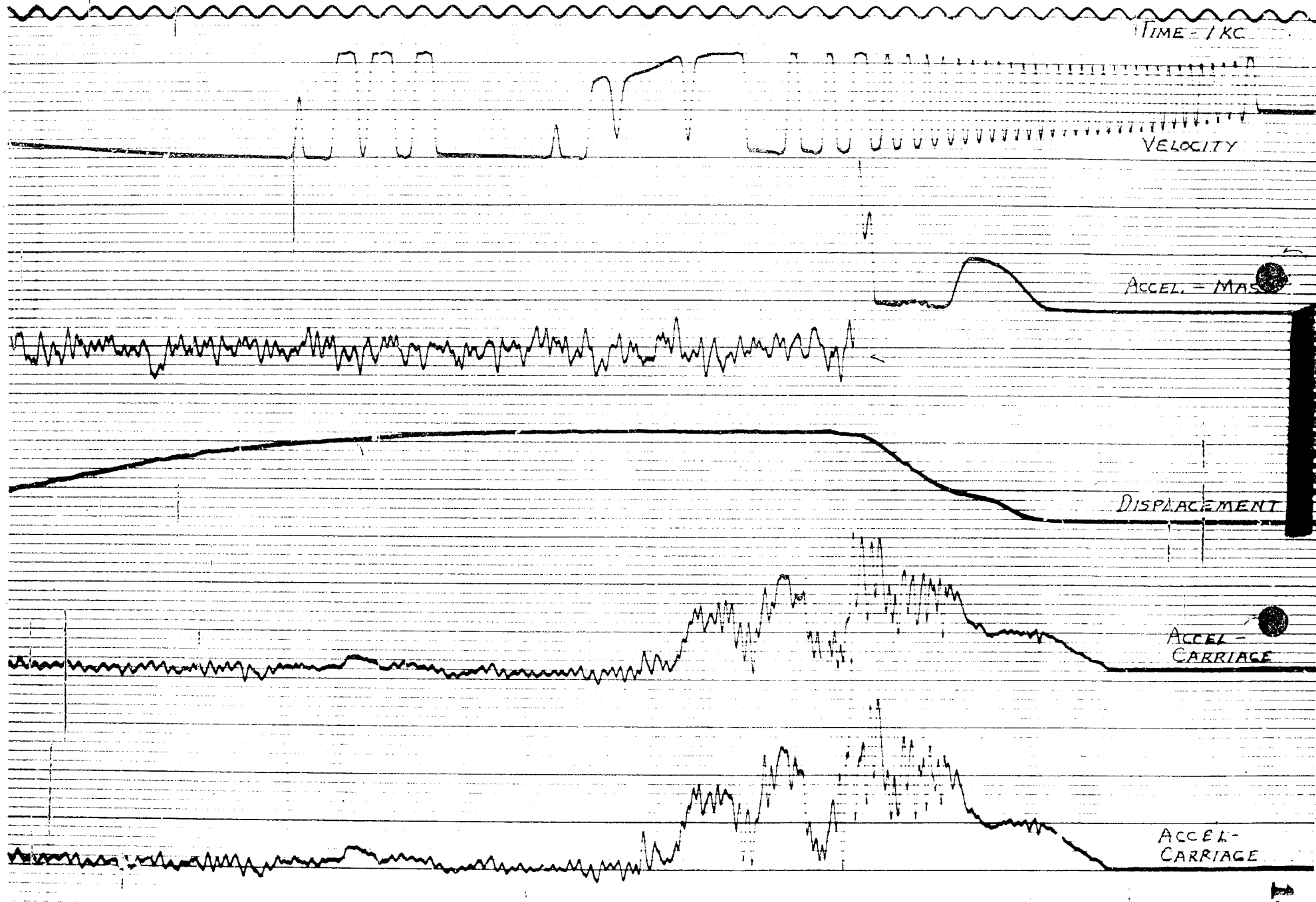

FIGURE 6. TYPICAL TEST RECORD - TEST 43

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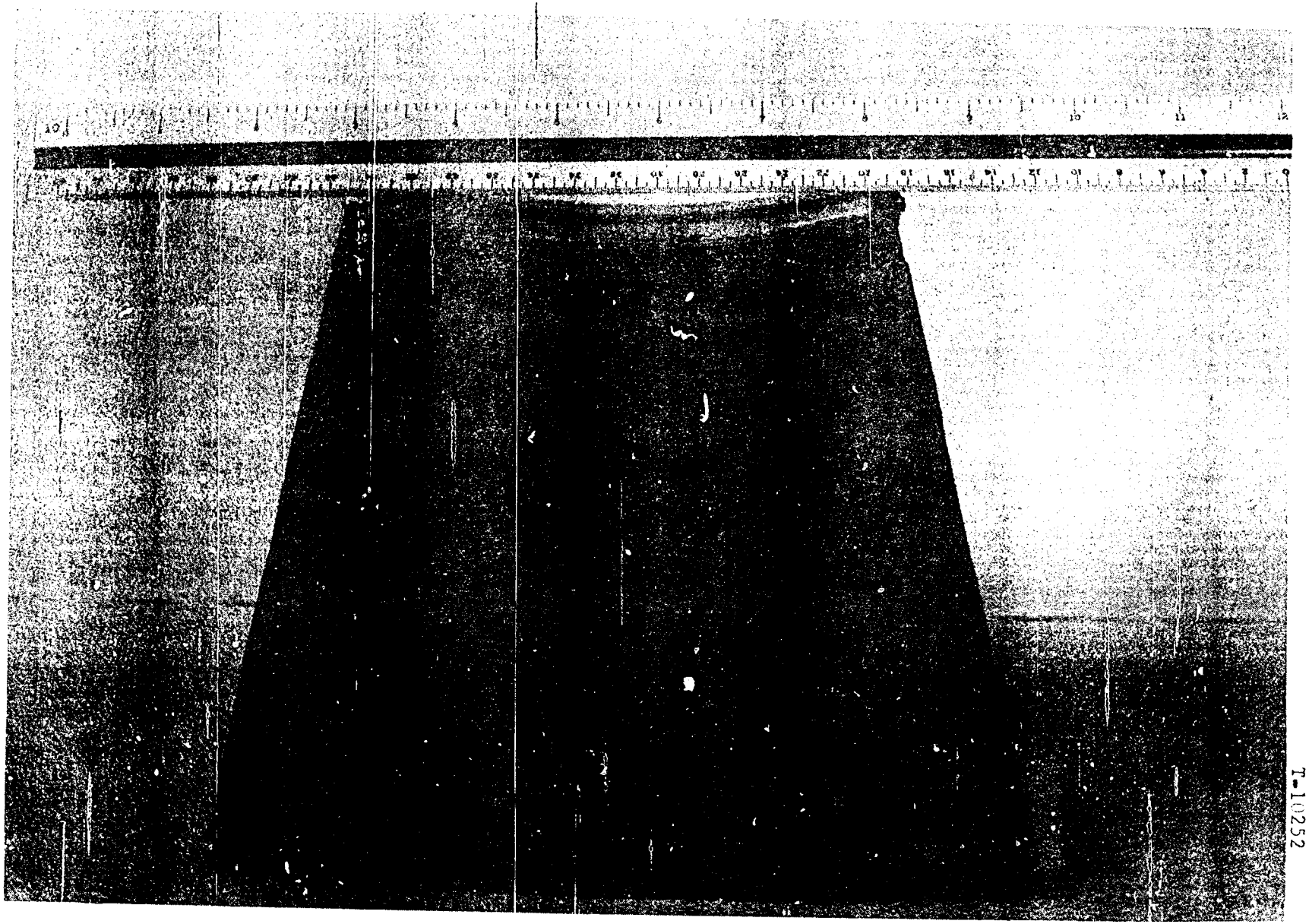

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FIGURE 7. LONG CURVED SPECIMEN - COMPRESSIVE FAILURE.

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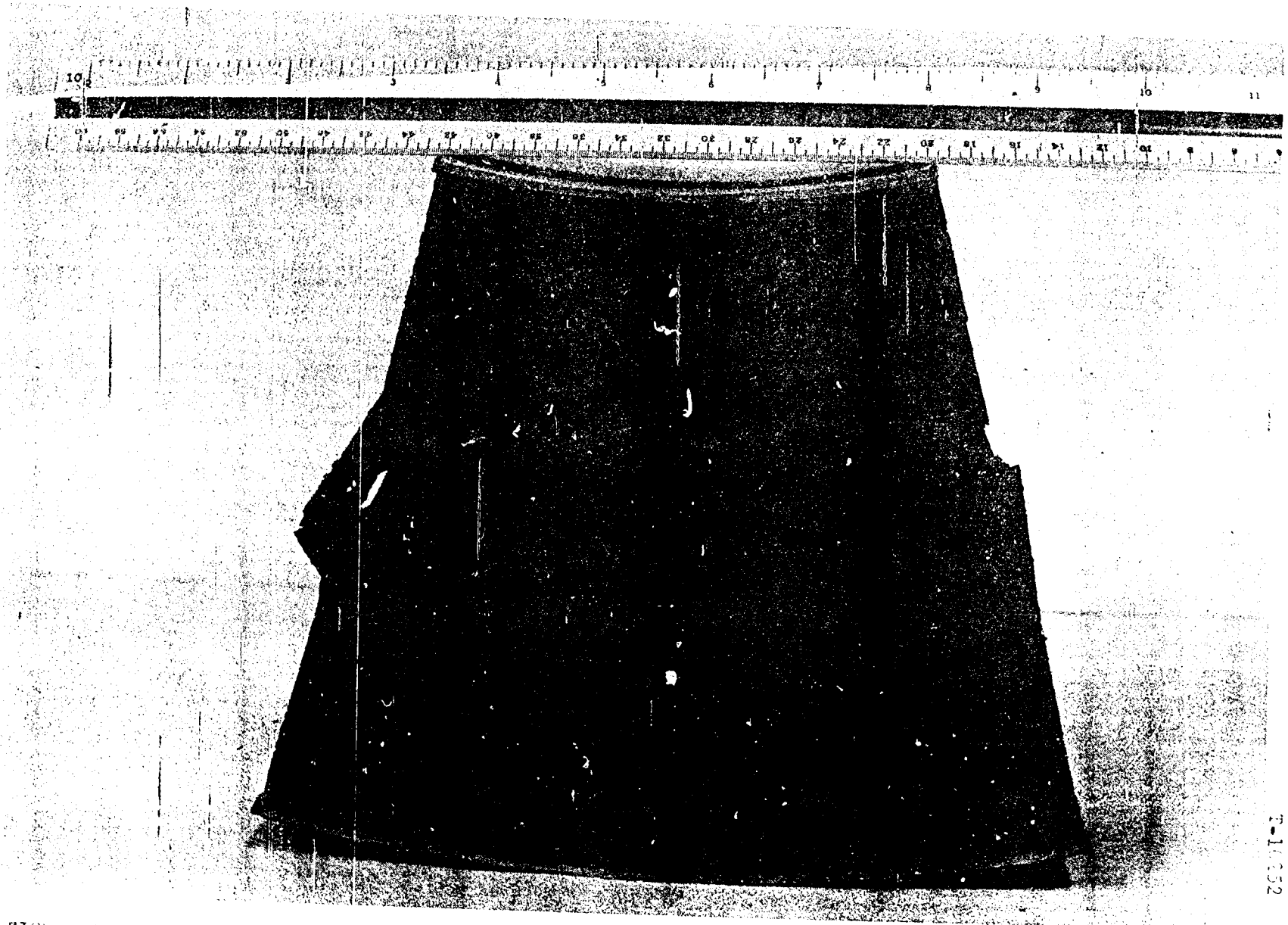

FIGURE 8. LONG CURVED SPECIMEN - COLUMN FAILURE.

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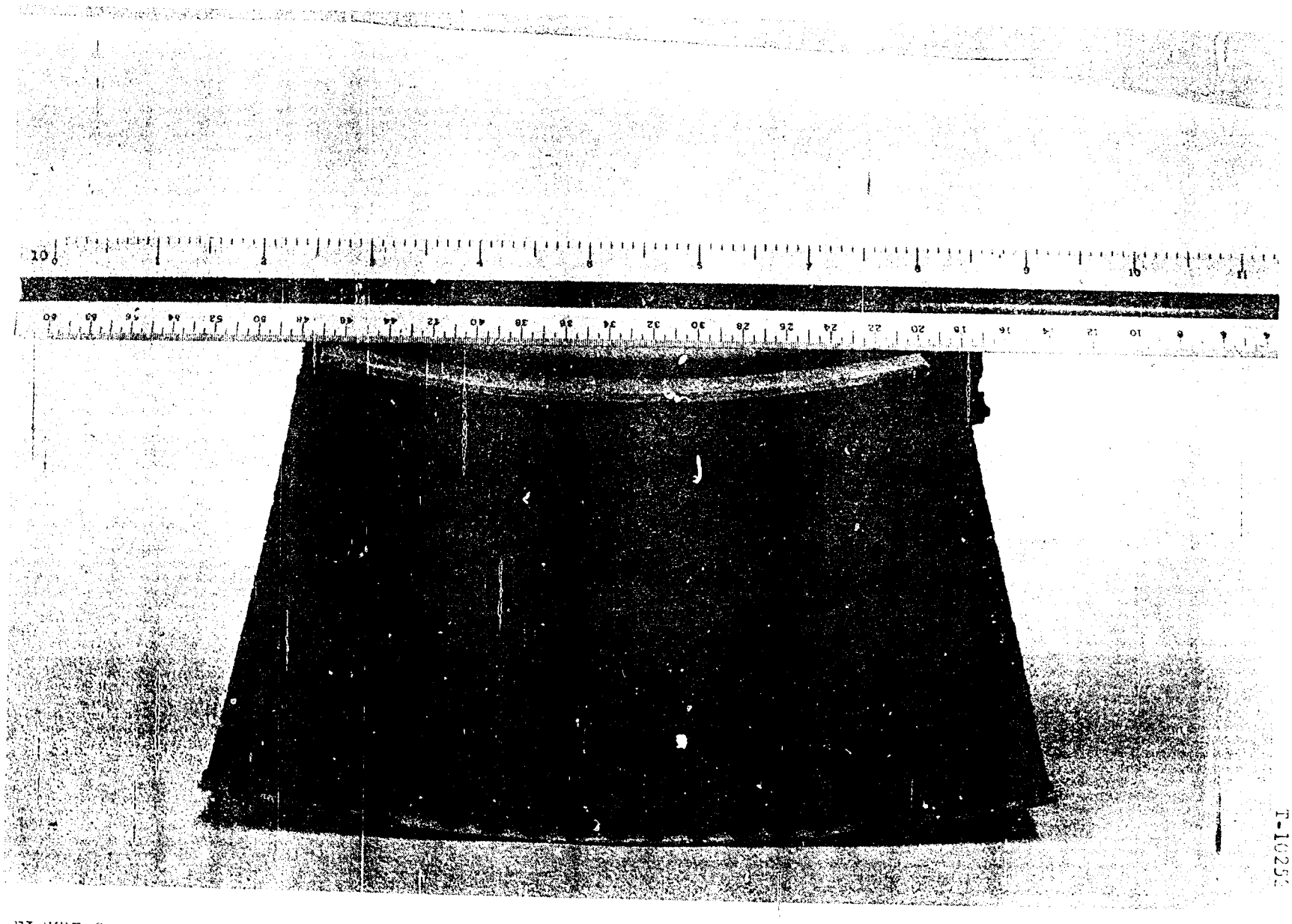

FIGURE 9. SHORT CURVED SPECIMEN - COMPRESSIVE FAILURE.

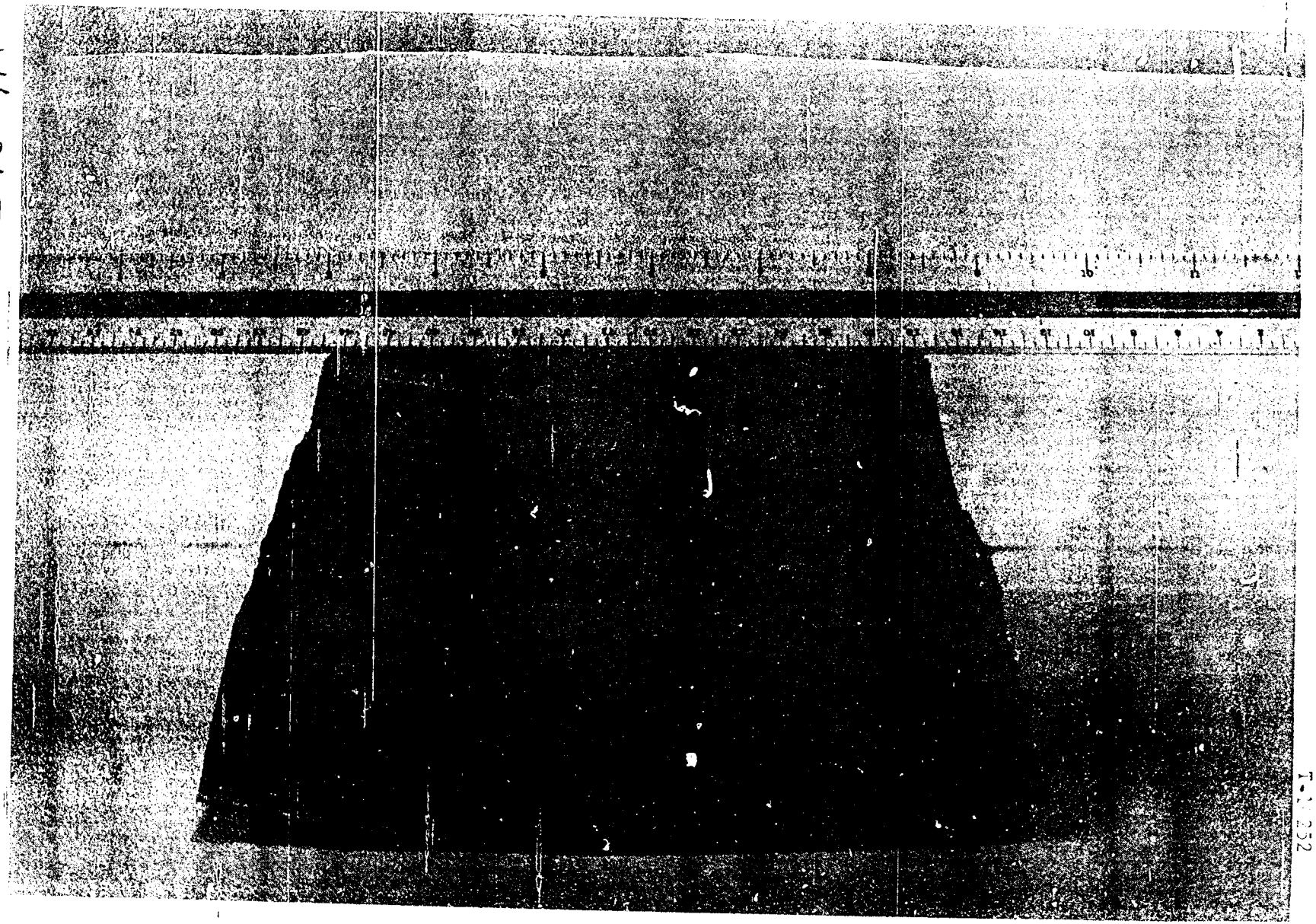

FIGURE 10. SHORT CURVED SPECIMEN - COLUMN FAILURE.

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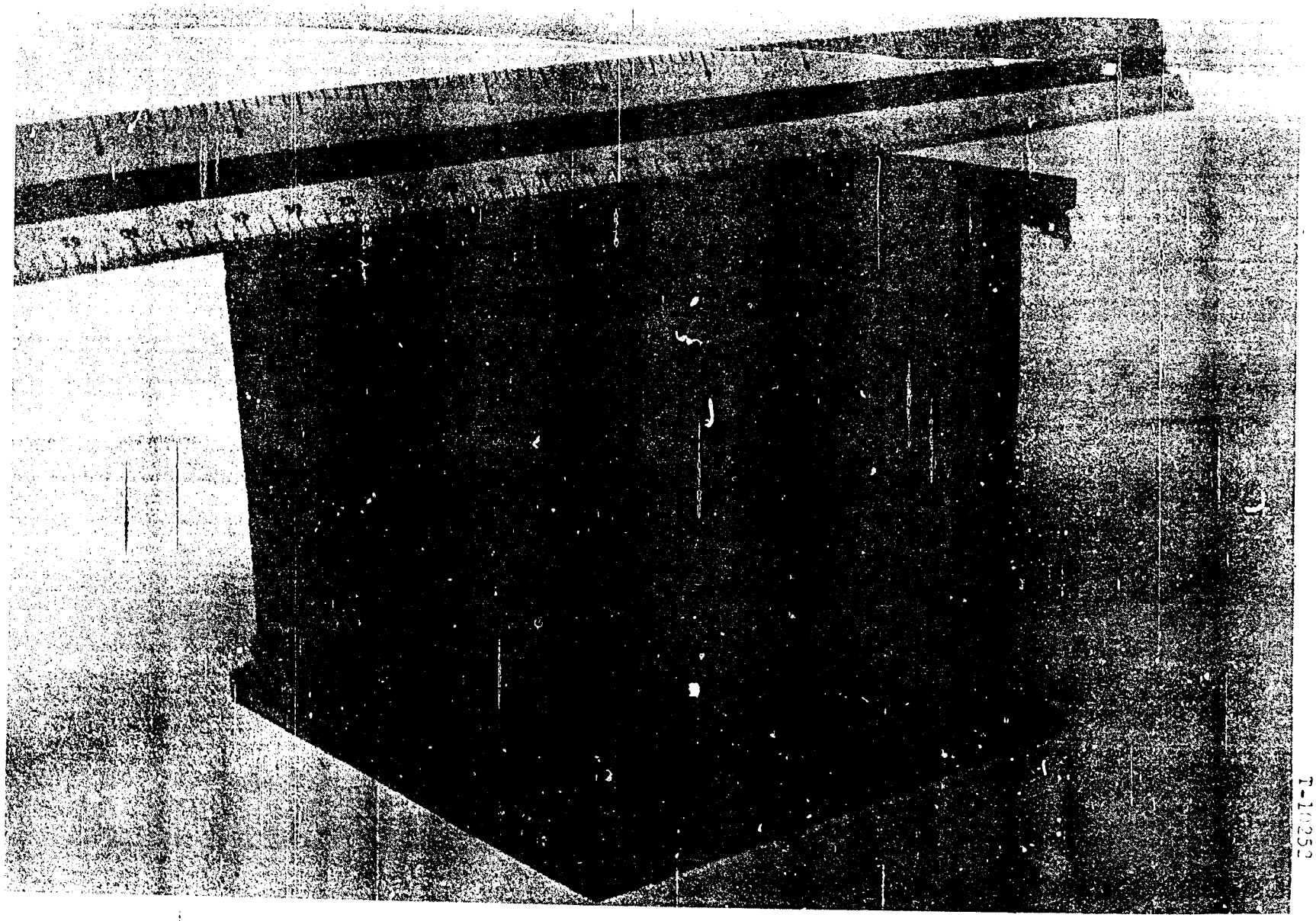

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FIGURE 11. FLAT BLOCK - COMPRESSIVE FAILURE.

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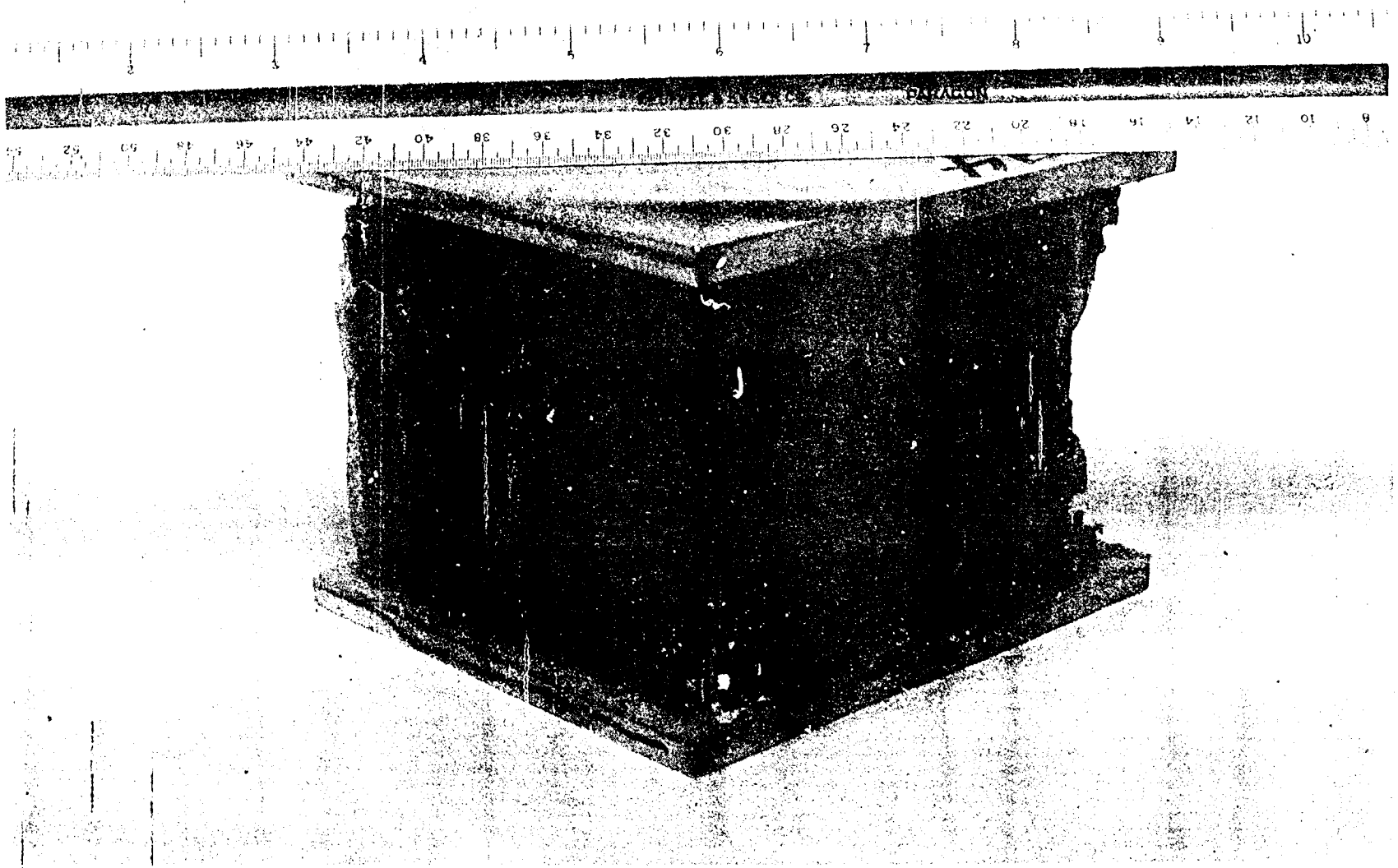

FIGURE 12. FLAT BLOCK - TYPICAL FAILURE.

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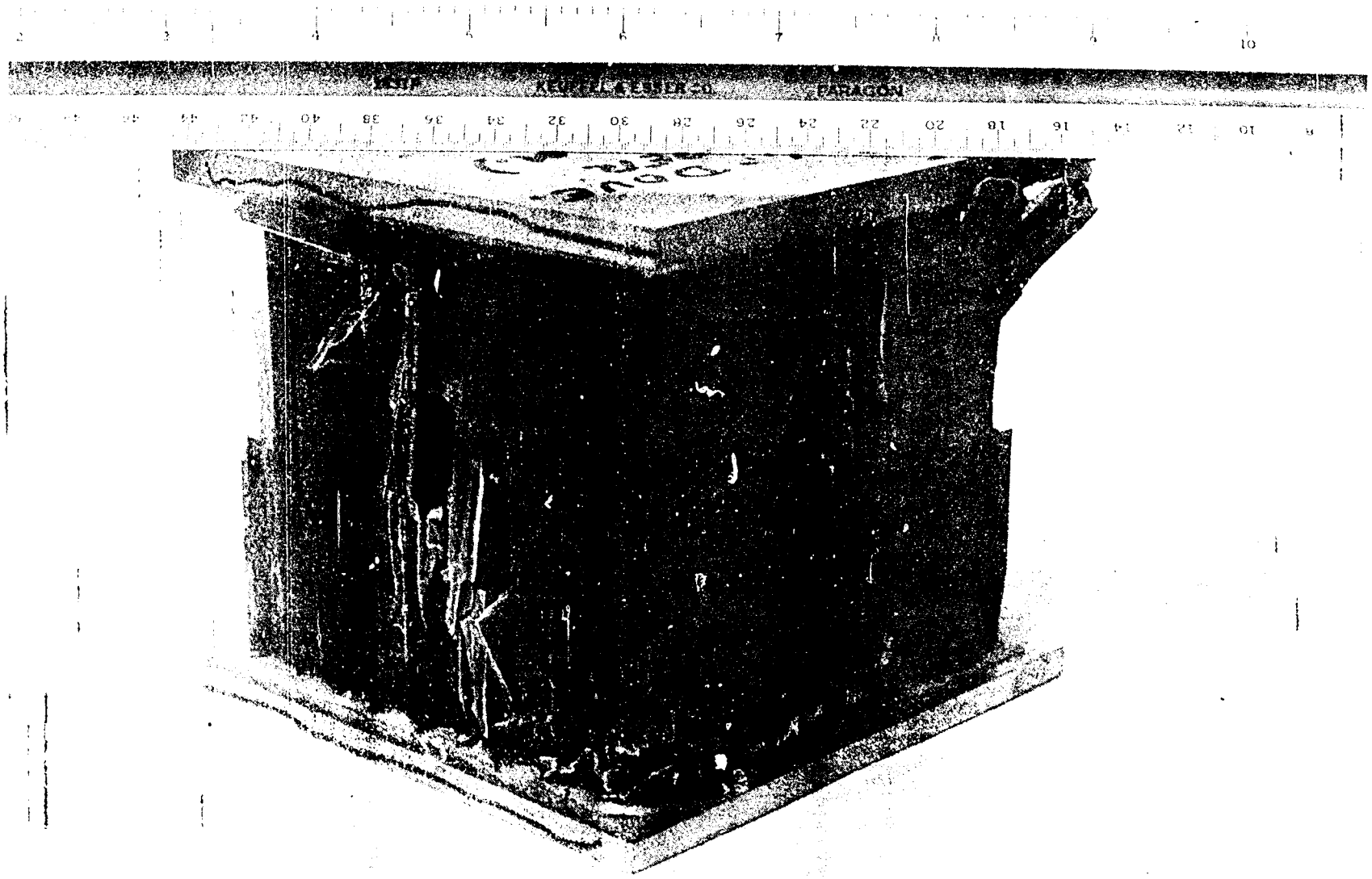

FIGURE 1[illegible]. FLAT BLOCK - TYPICAL FAILURE.

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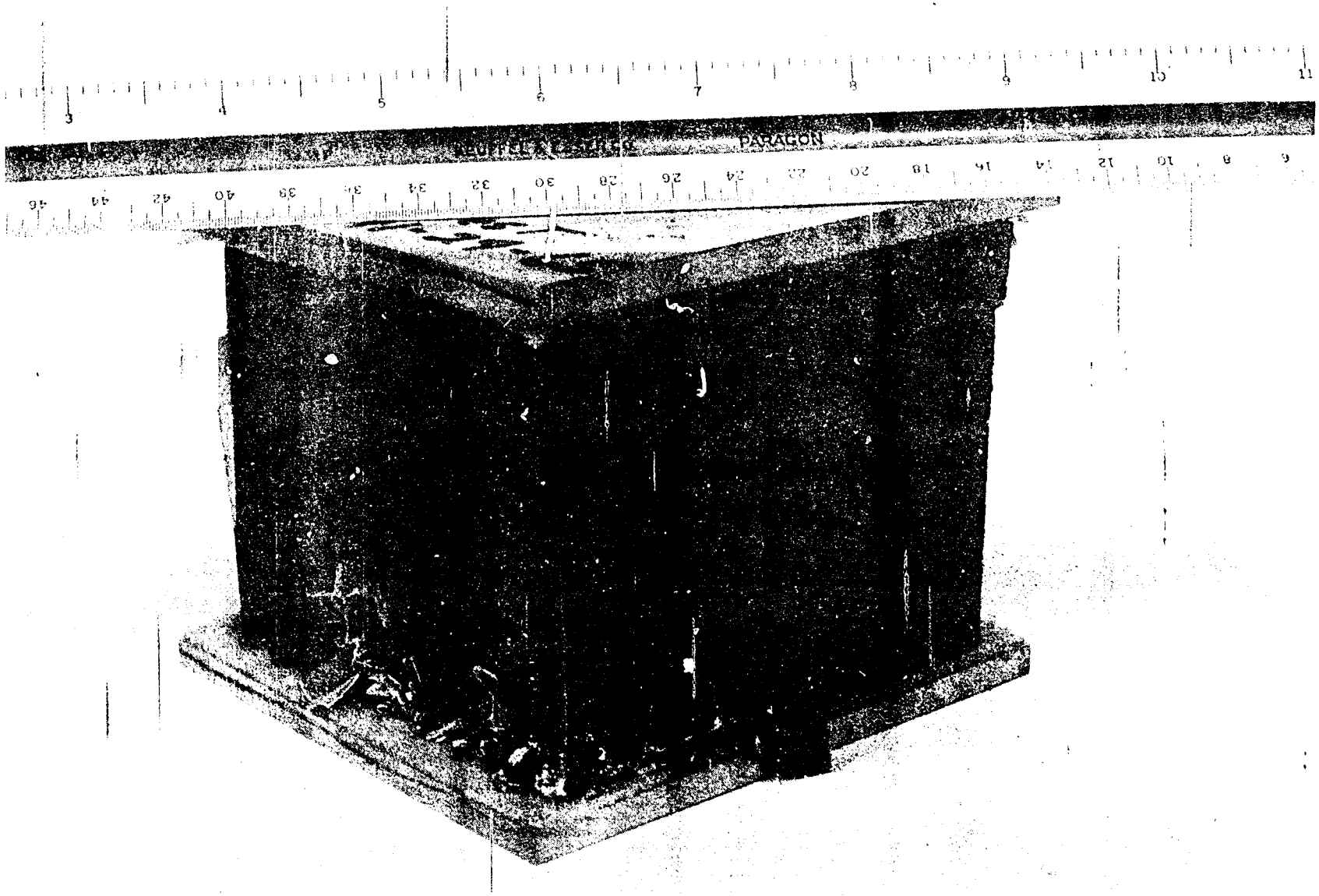
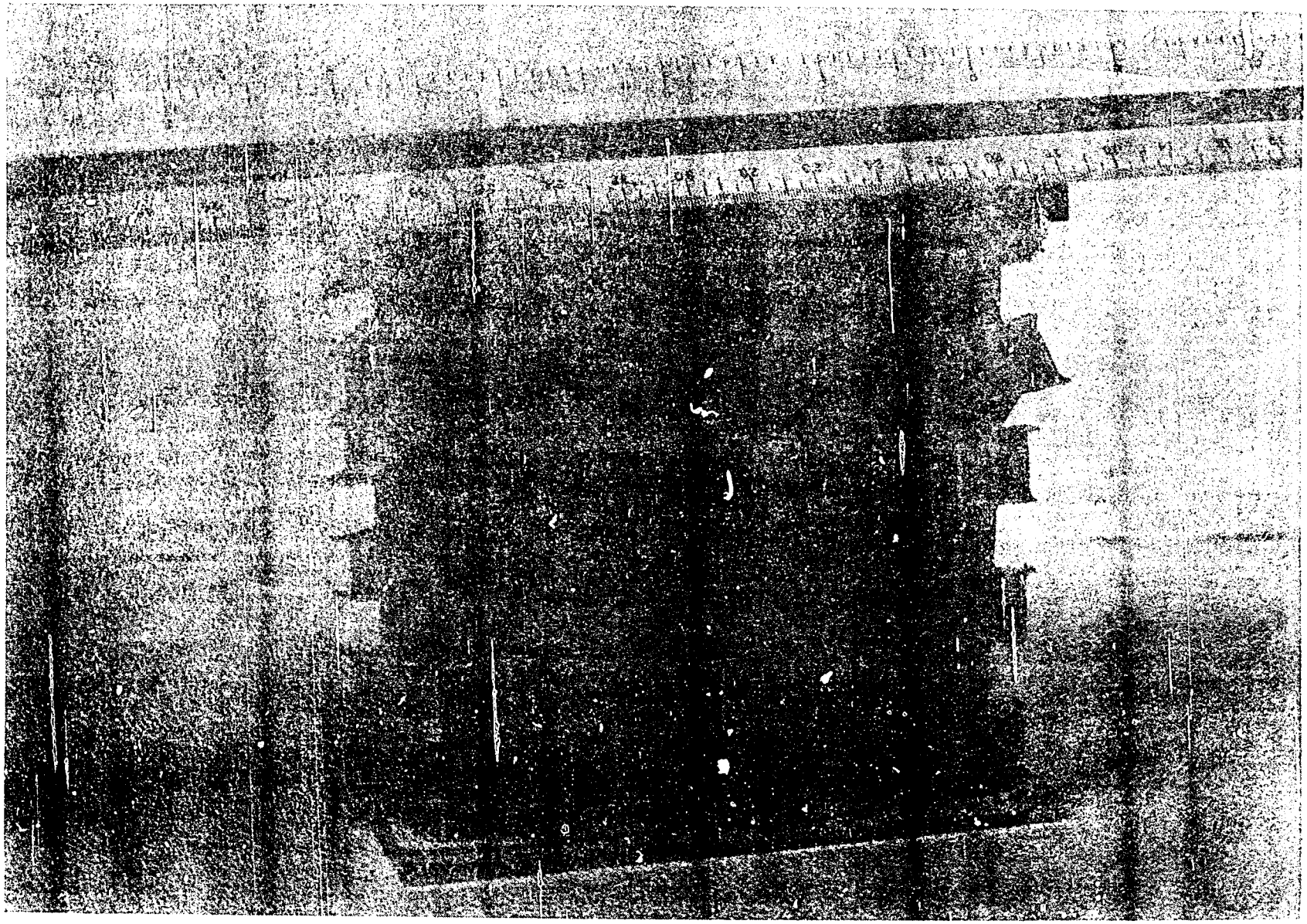


FIGURE 14. FLAT BLOCK - TYPICAL FAILURE.

#1428

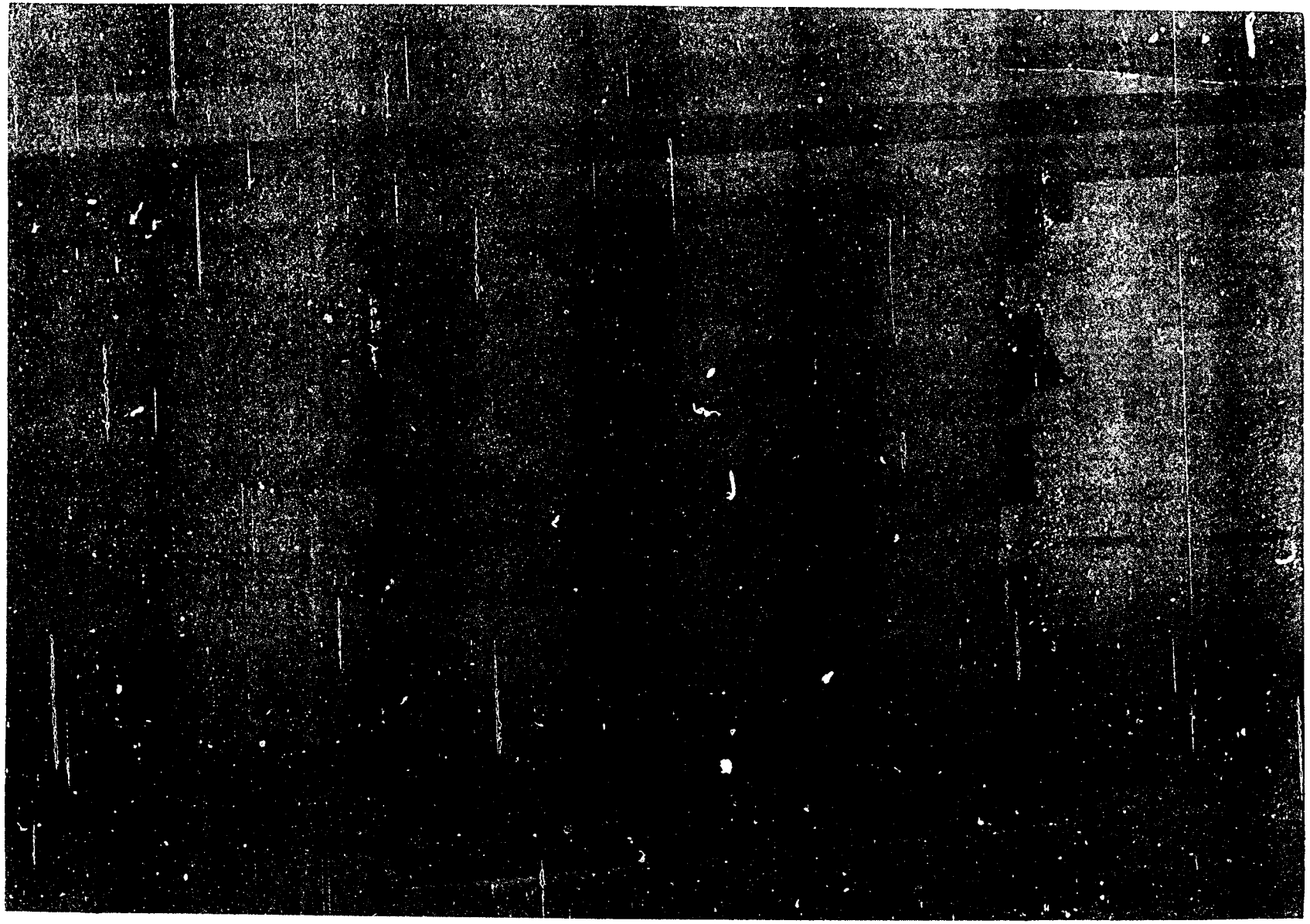


#1429

UNCLASSIFIED

D#66-360

[redacted]



[illegible] SOFT [illegible] - TYPICAL [illegible].

UNCLASSIFIED

[redacted]

#1429