BRL R 101

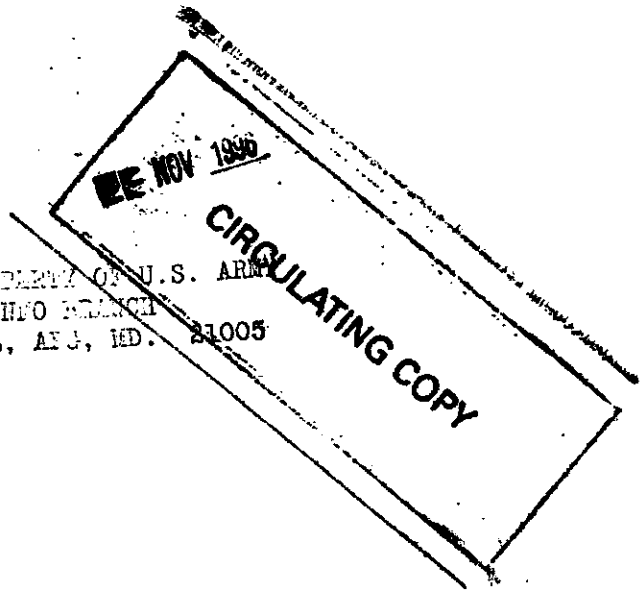
BRL

REPORT NO. 101

FOURTH PARTIAL REPORT ON RESEARCH ON ROCKET PROPULSION OF PROJECTILES

by

L. A. Skinner



April 1938

U.S. ARMY ABERDEEN RESEARCH AND DEVELOPMENT CENTER
BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

Report No. 101

LAS/emh
Aberdeen Proving Ground, Md.
April 28, 1938

FOURTH PARTIAL REPORT ON RESEARCH ON ROCKET PROPULSION OF PROJECTILES

Research Project RZ 101
Authority APG 121.2/12196

Abstract

Time-pressure curves were obtained with the piezo-electric gauge using the rocket driving charge which had been used in firings of free rocket projectiles as reported specifically in the "Third Partial Report on Research on Propulsion of Rocket Projectiles".

The results show the approximate peak pressures reached in the driving charge chamber of these rockets, the duration of burning and the pressures existing at any time between ignition and the return to zero in one case and nearly to zero in the others.

PREVIOUS REPORTS

First Partial Report on Research on Rocket Propulsion of Projectiles, O.P. 5191 A.P.G., Md., April 7, 1933. 0.0 475.75/859; A.P.G. 475/7112, Book 72.

An investigation of Erosion in Orifices Caused by Powder Gases at High Temperature and Velocity. Watertown Arsenal, May 7, 1934. Report No. 731/4.

Research on Rocket Propulsion of Projectiles. Research Project RZ 101, A.P.G. May 31, 1935, Report No. 7. A.P.G. 121.2/12196.

Second Partial Report on Research on Rocket Propulsion of Projectiles. Research Project RZ 101. A.P.G. 121.2/12196. July 29, 1936. Report No. 54.

Third Partial Report on Research on Rocket Propulsion of Projectiles. Research Project RZ 101. Report No. 95. Authority A.P.G. 121.2/12196.

General Description of Apparatus

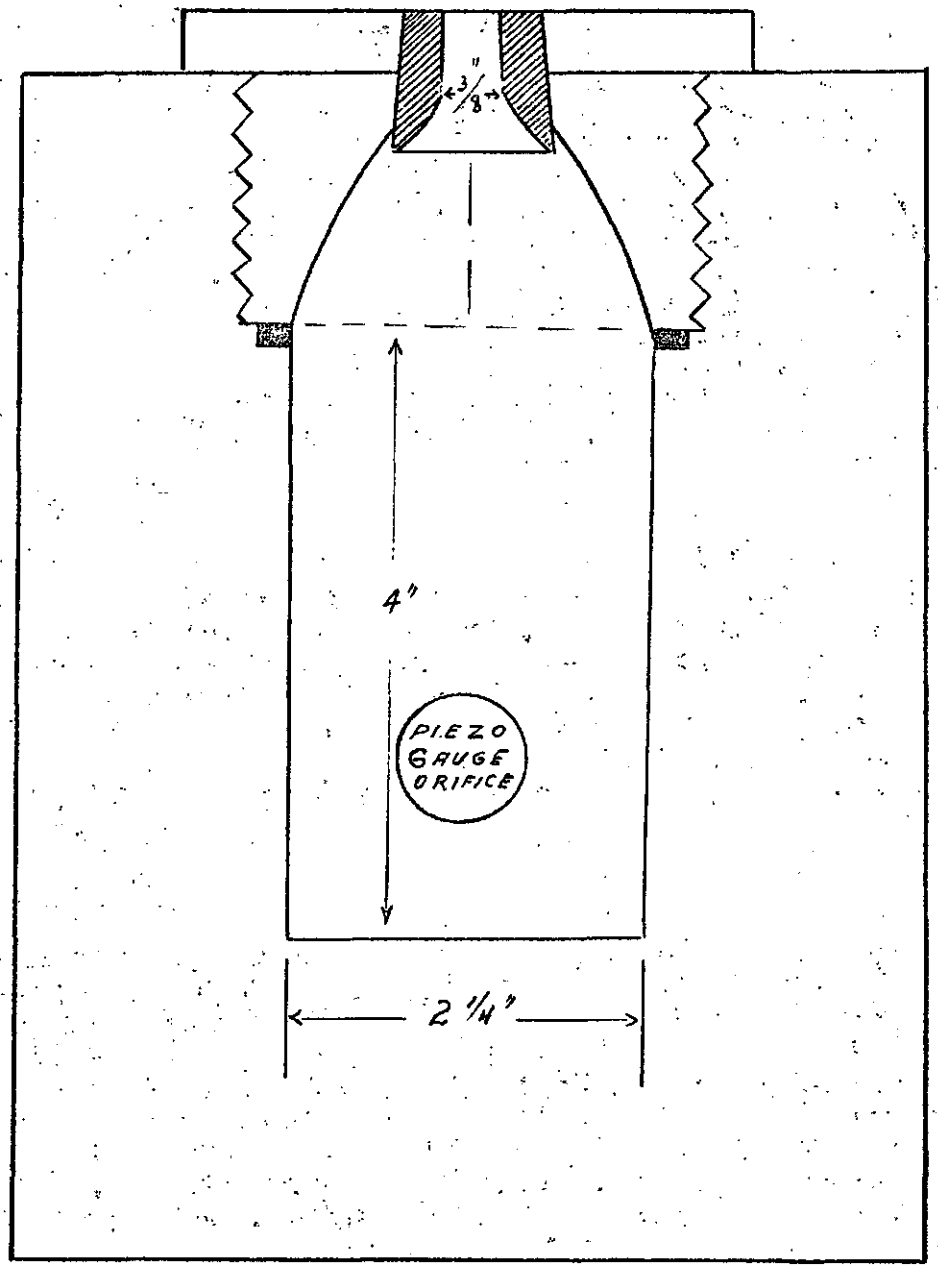
A steel cylinder having a chamber of approximately the same volume and shape as that of the rockets fired, was made. A breech block was provided and a holder for the orifice pieces so that a new orifice could be provided for each charge fired. A piezo gauge was mounted in the side of the cylinder and connected electrically to a recording cathode ray oscillograph. The charges were fired by means of an electric squib inserted through the discharge orifice and resting on the charge. A steel orifice piece with a 3/8" orifice was used and renewed for each charge in order to eliminate the effect on pressure that would result from the enlargement of orifice produced by a charge when fired.

Results

Attached in report are photostat copies of a portion of each curve record made. Three curves were selected for plotting as time-pressure curves. One of these (charge No 2) was recorded to give a record for the entire time of burning, the others for only part of the burning period. The curves show that peak pressures of about 6000 lb/in^2 were reached, that the total time of burning was about 1.2 seconds and that for about one-half of this time the pressure was over 800 lb/in^2.

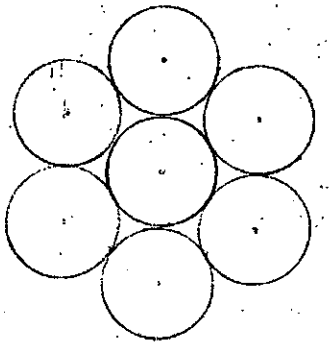
Discussion

The peak pressures indicated are undesirable because of the weight of metal in the driving charge chamber necessary to withstand them. Since steam velocities of about 4000 ft/sec. are obtained in turbine nozzles with less that 500 lb/in^2 it would appear that a powder that would give a long flat curve which would keep a pressure of about 2000 lb/in^2 during most of the time of burning, would give a sufficiently high jet velocity. The curves indicate that this powder although the most satisfactory used, falls far short of the desirable. It is realized that it will be difficult if not impossible to get a high potential powder composition and charge form that will give the



CHAMBER USED WITH PIEZO-ELECTRIC GAUGE IN MAKING ROCKET POWDER PRESSURE CURVES

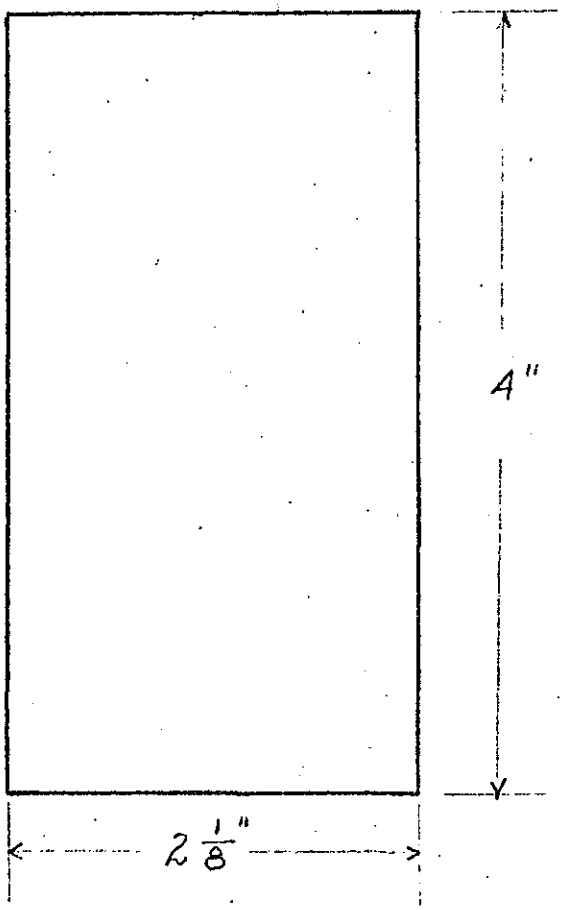
Powder Charge Used in Making Time-Pressure Curves.



Weight	234 Grams.
Nitrocellulose (13.15% N)	54%
Nitroglycerine	43%
Vaseline	3.0%
Diphenylamine (added)	0.65%
Diameter, Grain	.625"
Length, Grain	4.0"

Unperforated.

Sticks cemented together with acetone suspended N.H. Powder.



desired form of time-pressure curve with a fixed orifice, due to the powder characteristic of increased rate of burning as pressure increases. However, the possibility of using a variable orifice is worthy of consideration and experimental work along this line will be done as soon as time and conditions permit.

L. A. Skinner,
Capt., Ord. Dept.

H. H. Zorning,
Lt. Col., Ord. Dept.,
Chief Research Division

Round No 2

X cm.	Y cm.	Base cm.	Deflection cm.	Time sec.	Pressure lb/in.^{2}
23.5	7.447				
24	7.444	7.444	0	0	
24.5	7.431	7.449	.018		
24.7	7.417	7.451	.034	-.0054	60
24.9	7.379	7.453	.074	-.0047	196
25.0	7.322	7.454	.132	-.0043	400
25.1	7.202	7.455	.253	-.0039	708
25.2	6.971	7.456	.485	-.0036	1290
25.3	6.603	7.457	.854	-.0032	2070
25.4	6.008	7.458	1.450	-.0028	3260
25.5	5.539	7.459	1.920	-.0024	4200
25.6	5.177	7.460	2.283	-.0021	4424
25.7	4.920	7.461	2.541	-.0017	5368
25.8	4.756	7.462	2.706	-.0013	5760
25.85	4.700	7.425	2.7625	-.001	5880
25.9	4.656	7.463	2.807	-.0006	5990
25.95	4.635	7.435	2.8285	-.0004	6020
26.00	4.632	7.464	2.832	-.0002	
26.05	4.620	7.4645	2.8445	0	.6064
26.1	4.621	7.465	2.844	+.0001	6060
26.15	4.628	7.4655	2.8375	.0003	6035
26.2	4.638	7.466	2.828	.0005	6020
26.25	4.644	7.4665	2.823	.0007	6000
26.3	4.648	7.467	2.819	.0009	
26.35	4.657	7.4675	2.811	.0011	
26.4	4.668	7.468	2.80	.0012	5985
26.45	4.683	7.4685	2.786	.0014	
26.5	4.699	7.469	2.770	.0016	
26.55	4.714	7.4695	2.756	.0019	5884
26.6	4.729	7.470	2.741	.0020	
26.65	4.750	7.4705	2.721	.0022	
26.7	4.780	7.471	2.691	.0024	5750
26.8	4.832	7.472	2.640	.0027	
26.9	4.910	7.473	2.563	.0030	
27.0	4.979	7.474	2.495	.0034	5490
27.1	5.05	7.475	2.425	.0038	
27.2	5.121	7.476	2.355	.0042	
27.3	5.195	7.477	2.282	.0046	4800
27.4	5.266	7.478	2.212	.0049	
27.5	5.339	7.479	2.140	.0053	
27.6	5.419	7.480	2.070	.0057	4368
27.7	5.483	7.481	1.998	.006	
27.8	5.561	7.482	1.921	.0064	4200
27.9	5.628	7.483	1.855	.0066	
28	5.5681	7.484	1.803	.0072	3720

Round No 2

X cm.	Y cm.	Base cm.	Deflection cm.	Time sec.	Pressure lb/in.^{2}
28.2	5.5806	7.486	1.680	.0075	
28.4	5.915	7.488	1.573	.0083	
28.6	6.020	7.490	1.470	.009	
28.8	6.116	7.492	1.386	.0098	3156
29.	6.205	7.494	1.289	.0105	
29.5	6.381	7.499	1.118	.012	
30	6.530	7.504	.974	.014	2320
30.5	6.650	7.509	.859	.016	
31	6.745	7.514	.769	.018	
31.5	6.832	7.519	.687	.020	
32	6.888	7.524	.636	.022	1760
32.5	6.925	7.529	.604	.024	
33	6.954	7.534	.580	.025	1524
33.5	6.978	7.539	.561		1480
34	6.994	7.544	.550	.029	1456
35	7.045	7.554	.509		
36	7.079	7.564	.485	.036	1290
37	7.098	7.574	.476		
42	7.28	7.624*	.344	.059	976
52	7.29	7.624	.334		
62	7.295	7.624	.329	.429	916
77	7.310	7.624	.314	.643	860
97	7.538	7.624	.086	.903	248
112	7.624	7.624	0	1.213	0

* Drum stopped spiralling here

Rd. No. 3

X cm.	Y cm.	Base cm.	Deflection cm.	Time sec.	Pressure lb/in.^{2}
1	7.463				
2	7.463				
3	7.486	7.486	.000	-.01067	
4	7.485	7.4886	.003	-.00974	
5	7.494	7.4904	.003	-.00881	
6	7.499	7.4922	.003	-.00788	
7	7.499	7.4940	.004	-.00695	
8	7.498	7.4958	.002	-.00602	
9	7.479	7.4976	.019	-.00509	
9.5	7.464	7.4981	.034	-.00463	
10	7.397	7.4986	.102	-.004162	302
10.5	7.329	7.4991	.170	-.003697	500
10.7	7.110	7.4993	.389	-.003512	1080
10.9	6.970	7.4995	.530	-.003327	1400
11.0	6.883	7.4996	.617	-.003135	1640
11.2	6.681	7.4998	.819	-.002950	2033
11.4	6.464	7.5000	1.036	-.002765	2424
11.6	6.222	7.5002	1.278	-.002580	2960
11.8	5.980	7.5004	1.520	-.002395	3400
12.0	5.728	7.5006	1.773	-.002210	3900
12.2	5.508	7.5008	1.993	-.002025	4344
12.4	5.329	7.5010	2.172	-.001840	4600
12.5	5.224	7.5011	2.277	-.001748	4910
12.6	5.148	7.5012	2.353	-.001656	5070
12.7	5.076	7.5013	2.425	-.001564	5264
12.8	5.008	7.5014	2.493	-.001472	5346
12.9	4.942	7.5015	2.560	-.001380	5500
13.0	4.881	7.5016	2.621	-.001288	5600
13.1	4.815	7.5017	2.687	-.001196	5745
13.2	4.770	7.5018	2.732	-.001104	5820
13.3	4.734	7.5019	2.768	-.001012	5934
13.4	4.707	7.5020	2.795	-.000920	5950
13.5	4.661	7.5021	2.841	-.00828	6040
13.6	4.624	7.5022	2.878	-.00736	6120
13.7	4.599	7.5023	2.903	-.000644	6140
13.8	4.582	7.5024	2.920	-.000552	6160
13.9	4.564	7.5025	2.939	-.000460	6240
14.0	4.550	7.5026	2.953	-.000368	6260
14.1	4.541	7.5027	2.962	-.000276	6270
14.2	4.536	7.5028	2.967	-.000184	6290
14.3	4.533	7.5029	2.970	-.000092	6300
14.4	4.525	7.5030	2.978	0	6350
14.5	4.527	7.5031	2.976	+.000092	6340
14.6	4.532	7.5032	2.971	+.000184	6310

X cm.	Y cm.	Base cm.	Deflection cm.	Time sec.	Pressure lb/in.^{2}
14.7	4.531	7.5033	2.970	+.000276	6300
14.8	4.535	7.5034	2.968	+.000368	6280
14.9	4.541	7.5035	2.963	.000460	6275
15.0	4.545	7.5036	2.959	.000552	6267
15.2	4.557	7.5038	2.947	.000737	6250
15.4	4.572	7.5040	2.932	.000922	6235
15.8	4.614	7.5046	2.891	.001291	6128
16.0	4.630	7.5048	2.875	.001476	6117
16.2	4.645	7.5050	2.860	.001661	6076
16.4	4.666	7.5052	2.839	.001846	6040
16.6	4.686	7.5054	2.829	.002031	6036
16.8	4.711	7.5056	2.795	.002216	5950
17.0	4.730	7.5058	2.776	.002401	5940
17.5	4.798	7.5063	2.708	.002863	5760
18.0	4.866	7.5068	2.641	.003325	5664
18.5	4.937	7.5073	2.570	.003787	5555
19.0	5.013	7.5078	2.495	.004249	5343
19.5	5.084	7.5083	2.424	.004711	5260
20.0	5.154	7.5088	2.355	.005173	5074
20.5	5.228	7.5093	2.281	.005635	4920
21.0	5.308	7.5098	2.192	.006097	4736
21.5	5.389	7.5103	2.121	.006559	4560
22.0	5.471	7.5108	2.140	.007021	4480
22.5	5.553	7.5113	1.958	.007483	4280
23.0	5.634	7.5118	1.878	.007945	4140
24.0	5.789	7.5128	1.724	.008869	3800
25.0	5.930	7.5138	1.584	.009793	3620
26.0	6.064	7.5148	1.451	.010717	3264
27.0	6.179	7.5158	1.337	.011641	3064
28.0	6.290	7.5168	1.227	.012565	2832
29.	6.384	7.5178	1.134	.013489	2620
31	6.554	7.5196	.966	.015336	2308
33	6.694	7.5214	.827	.017183	2040
35	6.816	7.5225	.807	.019030	1990
37	6.918	7.5243	.606	.020877	1568
39	6.996	7.5261	.530	.022724	1400
41	7.036	7.5279	.492	.024571	1304
46	7.05	7.5324	.482	.029189	1285
56	7.09	7.5774	.467	.038425	1260
101	7.10		.465	.079987	1248

Rd. No 7

X cm.	Y cm.	Base cm.	Deflection cm.	Time sec.	Pressure lb/in.^{2}
1	8.097				
2	8.097				
3	8.097				
4	8.097	8.097	0	-.0053	0
4.5	8.088	8.100	.012	-.0046	
5	8.045	8.103	.058	-.0038	
5.2	7.989	8.104	.115	-.0035	352
5.4	7.904	8.105	.201	.0033	600
5.6	7.775	8.106	.331	.003	936
5.8	7.578	8.107	.529	.0027	1420
6.0	7.310	8.108	.798	.0024	2000
6.2	7.012	8.109	.987	.0021	2888
6.3	6.847	8.1096	1.263	.0019	
6.4	6.687	8.1102	1.423	.0018	3196
6.5	6.540	8.1108	1.571	.0016	
6.6	6.388	8.1114	1.723	.0015	3772
6.7	6.251	8.1120	1.861	.0014	
6.8	6.120	8.1126	1.993	.0012	4332
6.9	5.995	8.1132	2.118	.0011	
7.0	5.899	8.1138	2.215	.0009	4772
7.1	5.809	8.1144	2.305	.0008	
7.2	5.740	8.1150	2.411	.00066	5176
7.3	5.681	8.1156	2.435	.00052	
7.4	5.634	8.1162	2.482	.00048	
7.5	5.595	8.1168	2.522	.00032	5448
7.6	5.575	8.1174	2.542	-.00028	
7.7	5.562	8.1180	2.556	-.00014	5456
7.8	5.561	8.1186	2.558	0	5464
7.9	5.564	8.1192	2.555	+.00014	5454
8.0	5.567	8.1198	2.553	.00028	
8.1	5.574	8.1204	2.546	.00032	5440
8.3	5.588	8.121	2.533	.0006	
8.5	5.609	8.122	2.513	.00088	5372
8.7	5.636	8.123	2.487	.00166	
8.9	5.668	8.124	2.456	.00144	
9.2	5.746	8.142	2.396	.00186	5.56
9.5	5.832	8.160	2.328	.00228	
9.8	5.930	8.178	2.248	.0027	4852
10.1	6.026	8.196	2.170	.00312	4564
10.6	6.190	8.199	2.009	.00384	4360
11.1	6.351	8.202	1.951	.00456	4262
11.6	6.503	8.205	1.702	.00528	3784
12.1	6.642	8.218	1.576	.006	3516
12.6	6.771	8.221	1.450	.00672	3260
13.6	6.989	8.227	1.438	.0082	
14.6	7.167	8.233	1.166	.0096	2600
15.6	7.328	8.239	.911	.011	2188

Rd. No. 7

X cm.	Y cm.	Base cm.	Deflection cm.	Time sec.	Pressure lb/in^2
16.6	7.460	8.245	.785	.0125	1940
17.6	7.574	8.251	.677	.0139	1720
18.6	7.664	8.257	.593	.0154	1552
19.6	7.740	8.263	.523	.0168	1400
21.6	7.848	8.269	.421	.0196	1160
23.6	7.916	8.275	.359	.0226	1000
25.6	7.975	8.281	.306	.0254	862
30.6	8.168	8.287	.119	.033	352
35.6	8.289	8.293	.004	.040	
39.6	8.296	8.299	.003	.097	

4m — Partial Report on Rocket Propulsion of Projectiles.

Piezo Time-Pressure Curves

Rocket Driving Charge. Wt 234 Grams.

Form of Charge
End View

Characteristics of Powder.

Composition:

Nitrocellulose	(13.15% N)	94.0%
Nitroglycerine		43.0%
Vaseline		3.0%
Diphenylamine	(ABOVE)	0.45%

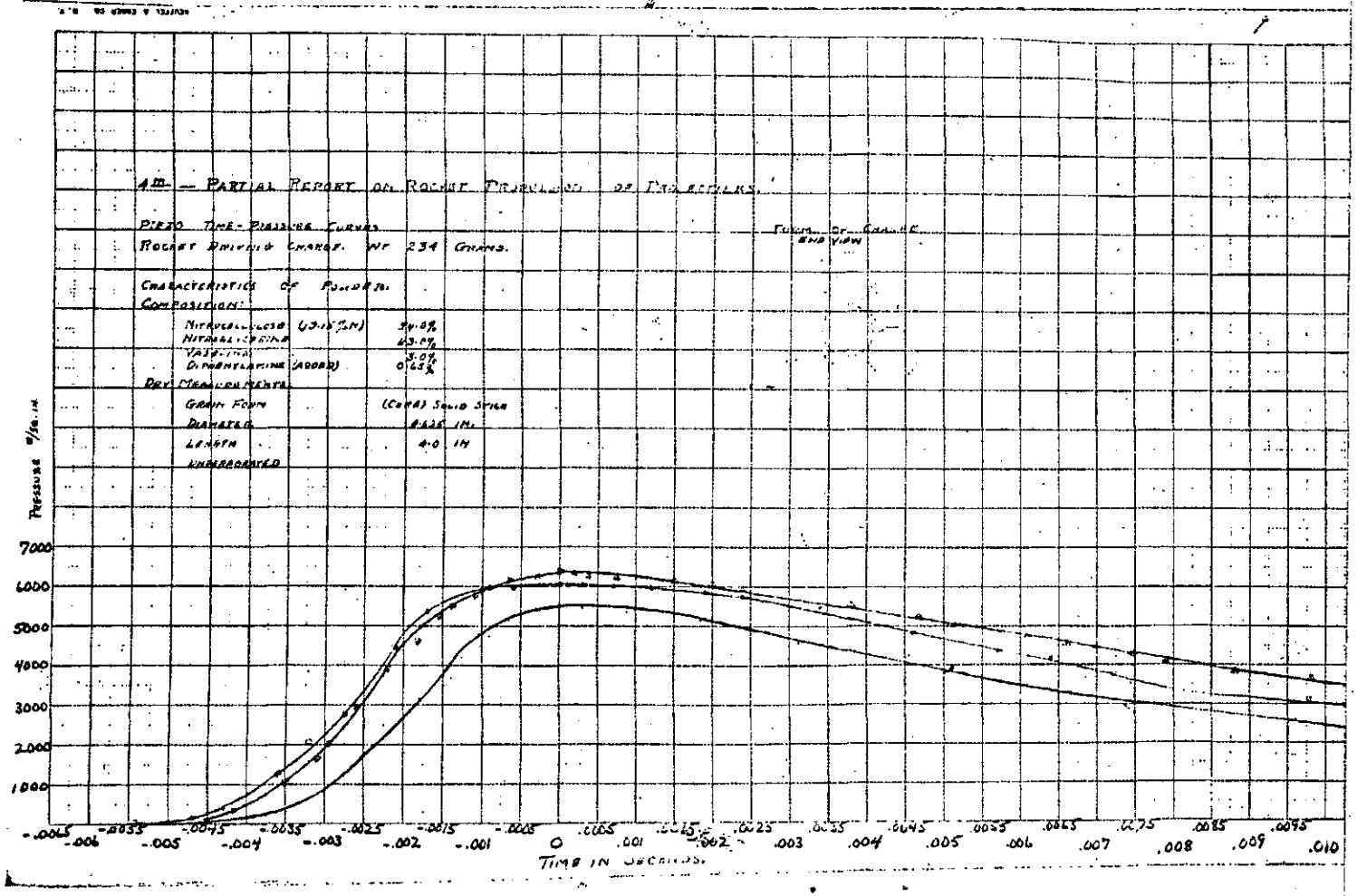
Dry Chemical Tests.

Grain Form (Cord) Solid String

Diameter 8.25 IN.

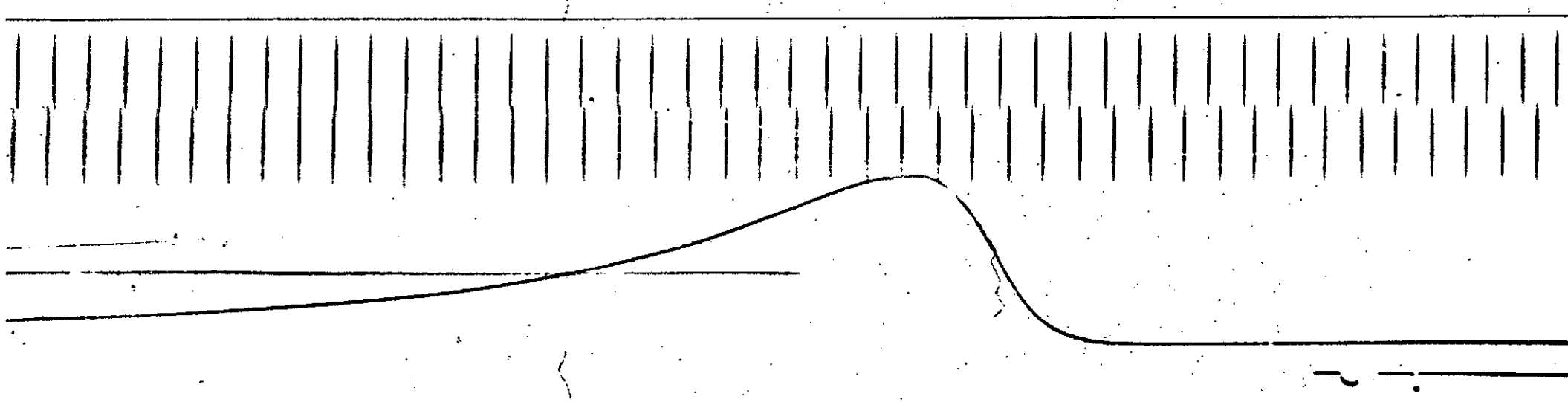
Length 4.0 IN

Unperforated

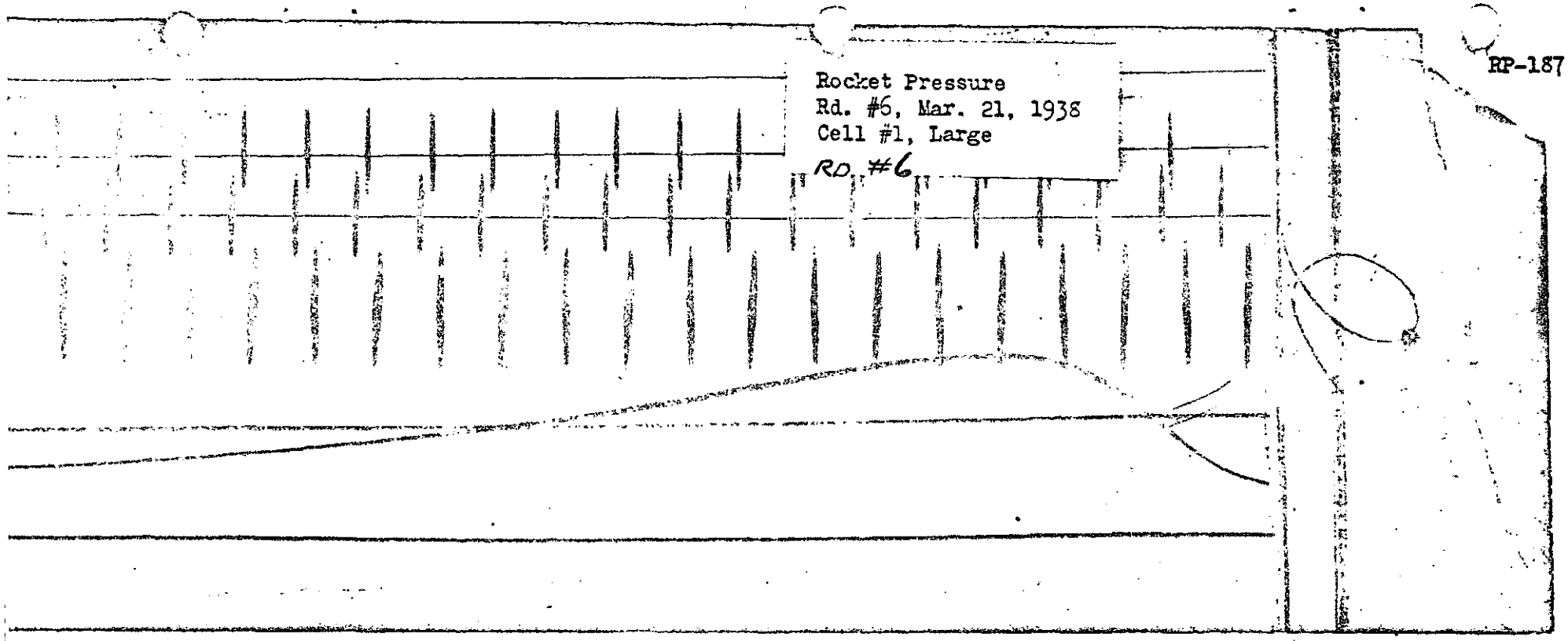


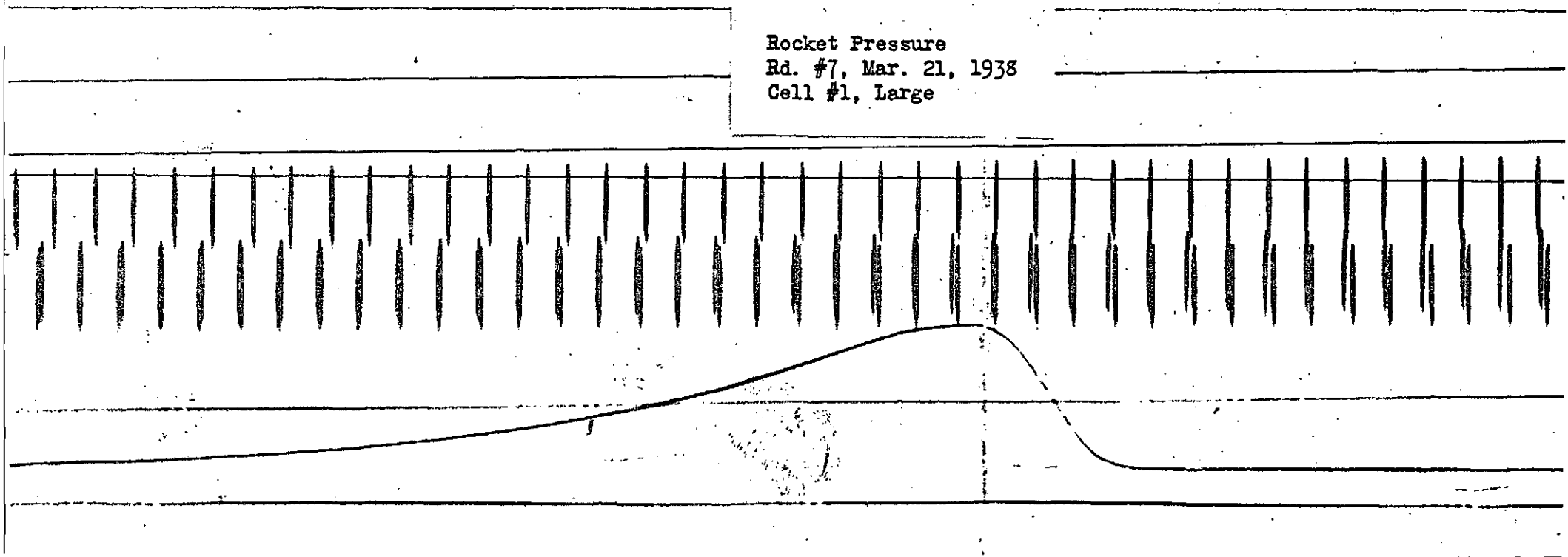
RP-186

Rocket Pressure
Rd. #8, Mar. 21, 1938
Cell #1, Large



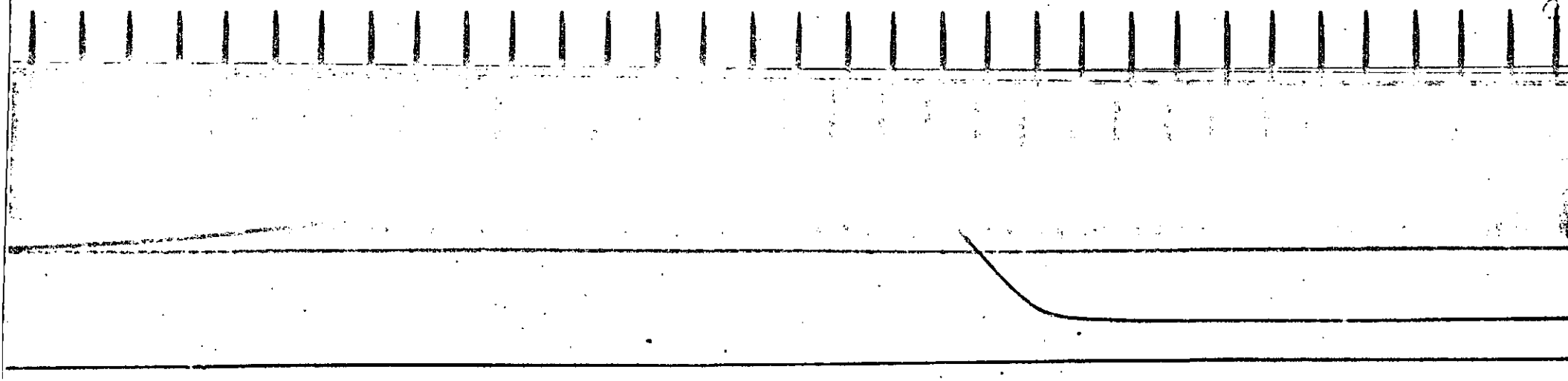
RP-187


Rocket Pressure
Rd. #6, Mar. 21, 1938
Cell #1, Large
RD. #6

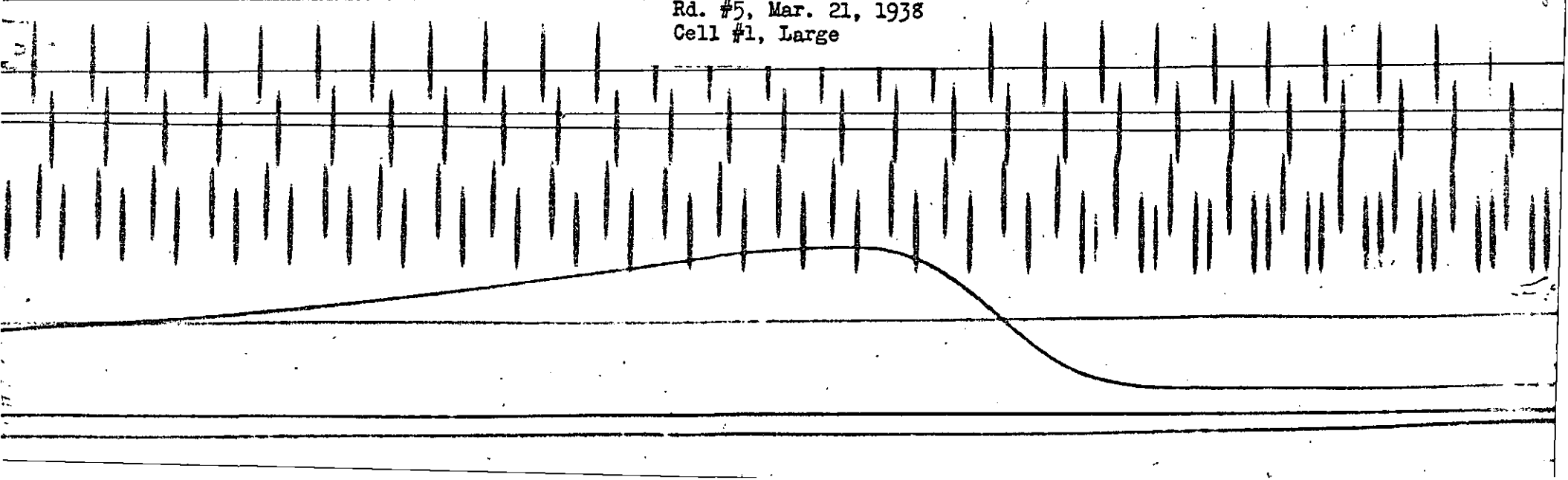

Rocket Pressure
Rd. #7, Mar. 21, 1938
Cell #1, Large

RP-188

Rocket Pressure
Rd. #4, Mar. 21, 1938
Cell #1, Large
Rd. #4

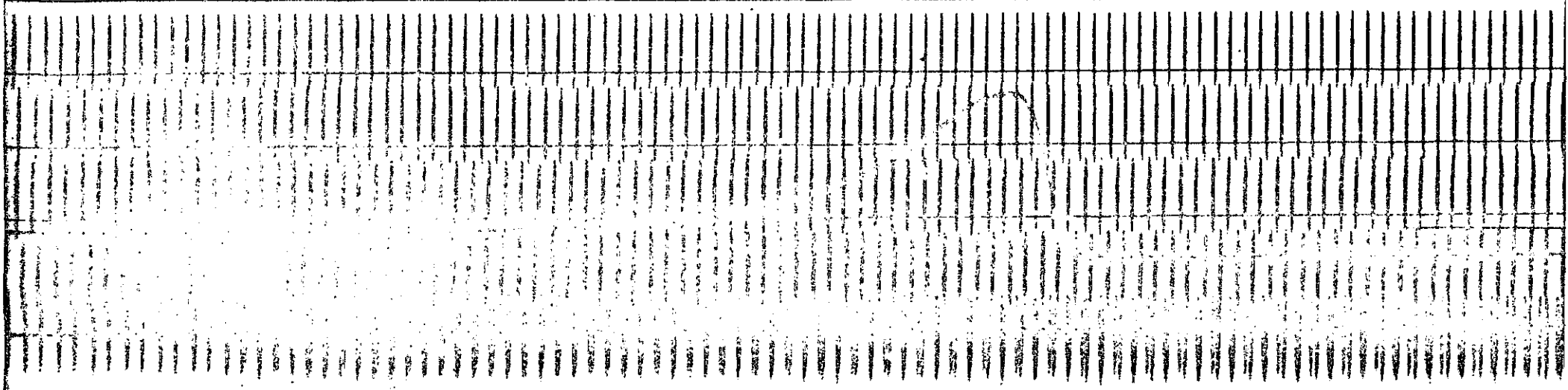


Rocket Pressure
Rd. #5, Mar. 21, 1938
Cell #1, Large

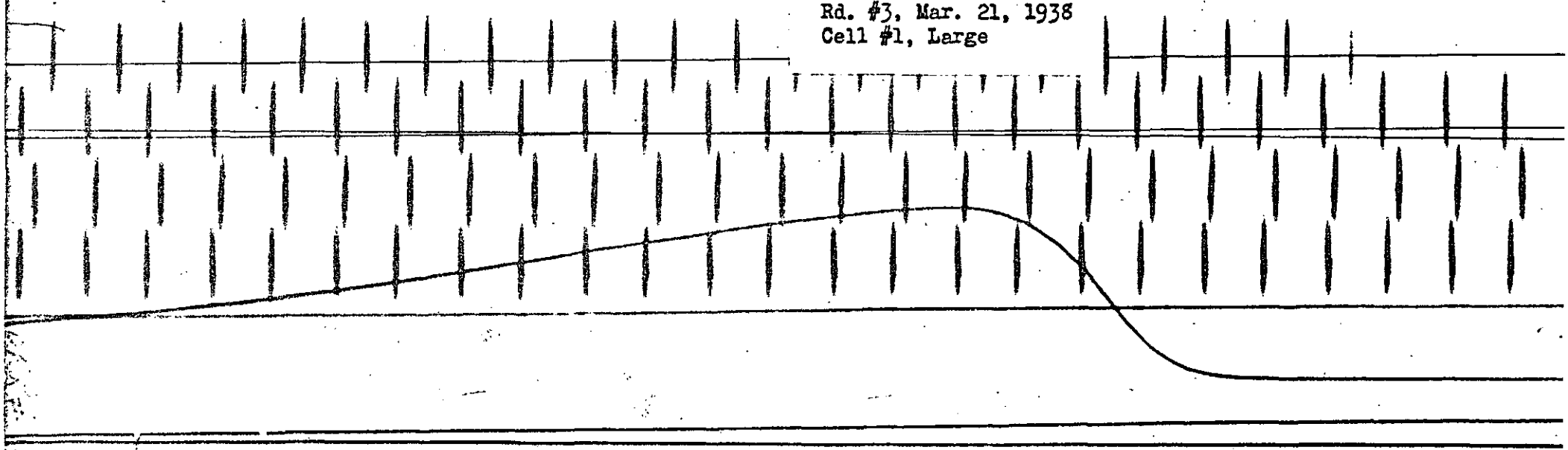


RP-189

Rocket Pressure
Rd. #2, Mar. 21, 1938
Cell #1, Large
RD. # 2



Rocket Pressure
Rd. #3, Mar. 21, 1938
Cell #1, Large



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DATE	DOC. CLASS.	COUNTRY	LANGUAGE	PAGES	ILLUSTRATIONS
Apr '38	Unclass.	U.S.	Eng.	16	13 photos, diagrs

ABSTRACT:

Rocket time-pressure curves were obtained with a piezoelectric gage using the rocket-driving charge which had been used in previous tests. The test results show the approximate peak pressures reached in the driving-charge chamber of these rockets, the duration of burning, and pressures existing at any time between ignition and return to nearly zero. Photostatic records of the trails are included.

DISTRIBUTION:

DIVISION: Power Plants, Rocket (4)
SECTION: Performance (10)

ATI SHEET NO.: R-4-10-3

SUBJECT HEADINGS: Engines, Rocket - Performance (34121); Propellants, Solid - Performance (75457.8); Combustion - Pressure (23640)