Astronuclear
Laboratory

WANL-TMI-1753

VERIFICATION OF HEIGHT VERSUS ACCELERATION CURVE
ON THE HIGH IMPACT SHOCK MACHINE (MODEL SH-2)

Prepared By

J. R. Mendicino
J. R. Mendicino

Sensor Development
Electronics and Instrumentation

PROPERTY OF
LIBRARY
WESTINGHOUSE ELECTRIC CORP.
ASTRONUCLEAR LABORATORY
PITTSBURGH, PA.

Approved By

MASTER

G. A. Remley
G. A. Remley, Acting Supervisor
Sensor Development
Electronics and Instrumentation

INFORMATION CATEGORY

Unclassified

G. A. Remley 4-13-67
Authorized Classifier Date

R. W. Kaisner
R. W. Kaisner, Manager
Instrumentation Systems and Facilities Support
Electronics and Instrumentation

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISTRIBUTION OF THIS DOCUMENT UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
1.0	Purpose -----	1
2.0	Equipment -----	1
2.1	Khron-Hite Band Pass Filter -----	1
2.2	Tektronix Oscilloscope -----	2
2.3	High Impact Shock Machine -----	2 - 3
2.4	Test Weights -----	3
2.5	Spring Number 55 -----	3
2.6	Accelerometer -----	3 - 4
3.0	Calculations -----	4 - 5
4.0	Recommendations -----	5
5.0	Conclusions -----	6

APPENDIX A- INSTRUCTION MANUAL
HIGH IMPACT SHOCK MACHINE
ASSOCIATED TESTING LABORATORIES, INC.

APPENDIX B- MILITARY STANDARD - 202C
12-SEPTEMBER-1963

LIST OF CURVES, PHOTOS, AND FIGURES

	<u>PAGE</u>
CALIBRATION CURVE FOR 1.5 ^{lb} LOAD -----	6a
PHOTOS OF IMPULSES FOR 1.5 ^{lb} LOAD -----	7
CALIBRATION CURVE FOR 5.0 ^{lb} LOAD -----	10
PHOTOS OF IMPULSES FOR 5.0 ^{lb} LOAD -----	11
 FIGURE 1 SHOCK MEASUREMENT SETUP WITH -----	 13
TRIGGERING SWITCH	
 FIGURE 2 DIAGRAM OF SHOCK MACHINE BASE PLATE -----	 14

Report on:

VERIFICATION OF HEIGHT VERSUS ACCELERATION CURVE
ON THE HIGH IMPACT SHOCK MACHINE (MODEL SH-2)

I. Purpose:

The purpose of this test was to verify the calibration curve provided by the manufacturer's of the shock machine in accordance with their specifications. A secondary goal was to establish a standard procedure for running a shock test with this machine.

II. Equipment:

The equipment to be used for the test is as follows:

1. Khron-Hite Band Pass Filter
2. Tektronix Oscilloscope (Model 502A)
3. High Impact Shock Machine (Model SH-2) Manufactured by Associated Testing Laboratories, Incorporated in accordance with Military Standard 202C, 12 September 1963. See Appendix B.
4. Test Weights - 1.5 lbs, 5 lbs.
5. Spring No. 55
6. Accelerometer (Endevco Model 2215D)

1. Khron-Hite Band Pass Filter

The pass band of the filter is set to give the lowest frequency cutoff attainable. In the case of the Khron-Hite Model 330-M this frequency cutoff is set for about twice the computed generator frequency. This frequency is dependent on the time duration of the anticipated shock impulse. In this test the expected time duration for a half-sinusoidal shock impulse for the 1.5^{lb} test weight is 8.0 ms + 1 ms and 8.5 ms + 1 ms for the 5^{lb} weight. The period of a full sine wave is then 16 + 2 and 17 + 2 milliseconds, respectively. The frequency is then computed from the following:

$$f = \frac{1}{T} = \frac{1}{16+2} \text{ and } \frac{1}{17+2}$$

which gives 55.5 to 71.5 cps
and 52.5 to 66.5 cps

Taking twice these values gives

111 to 143 cps
and 105 to 133 cps

The pass band was arbitrarily set at 120 cps for the entire test for both the 1.5^{lb} and 5^{lb} test weights.

2. Tektronix Oscilloscope

The scope is set to trigger so that a trace begins just before impact of the assembly carriage. See Figure 1. The vertical trace of the scope is inverted so that the shock pulse appears as a positive half-sine wave.

3. High Impact Shock Machine (Model SH-2). See Appendix B

A major requirement was that the machine be mounted on a level concrete floor. For added rigidity the shock machine was first securely mounted to a one-inch thick steel plate which, in turn, was anchored to the floor and a footer beneath. A diagram of this base plate is shown in Figure 2.

A few mechanical modifications were necessary and are as follows:

- (a) The carriage assembly was welded to give the equivalent of single-piece construction.
- (b) The guide rods had to be replaced because they had become bent. The reason for this was found to be the restraining mechanism used to prevent the carriage from striking the anvil a second time. For this reason the restraining mechanism was removed.

- (c) Teflon bushings were inserted in the holes where the guide rods pass through the test plate. The bushings allowed the carriage to ride down the rods more smoothly allowing consistent shock impulses.

4. Test Weights - 1.5 and 5lbs

The test weights were cleaned with J-Wax to remove accumulated rust.

5. Spring No. 55

Pulse Shape - Half Sine Wave

Time Duration (ms) - 6.0 to 11.0

"G" Level - 30 to 160

6. Accelerometer (Endevco Model 2215D)

Endevco Accelerometer Calibration

Model - 2215D Serial KA42 Type VIII

Sensitivity in Peak Mv/Peak g - 16.3

Sensitivity in rms Mv/Peak g - 11.5

Accelerometer Capacity in pf - 9725

Sensitivity in Peak p coulombs/Peak g - 163

300 pf total external capacity added for all sensitivity calibrations.

National Bureau of Standards Calibration

A check was made on the NBS calibration for the 2215D accelerometer. The only calibration dealt with in this test was that of frequency response. Frequency calibration over a broad range can be accomplished by a comparison method. A previously calibrated accelerometer or standard is compared against an unknown.

The test accelerometer and the calibrated accelerometer were mounted back to back with their sensitive axes coinciding on a fixture attached to a vibration generator (in this case, a 50 pound shaker table).

The data following shows frequency range, value of reference accelerometer (mv PK), and the voltage ratio output of the two accelerometers. An average value of these ratios was found to give an experimental value of 1.150. This value is the same as was calibrated by NBS.

<u>Frequency (cps)</u>	<u>Reference (8.35 mv rms)</u>	<u>Ratio</u>
36	10G Peak	1.170
50	"	1.163
75	"	1.163
100	"	1.165
150	"	1.163
200	"	1.156
250	"	1.154
300	"	1.154
400	"	1.144
500	"	1.144
700	"	1.144
1000	"	1.140
1500	"	1.130
2000	10G Peak	1.124

III. Calculations:

The formula for computation of the corrected sensitivity of this particular test is as follows:

$$E = E_c \frac{(C_p + C_c)}{(C_p + C_t)} \text{ Rms mv/peak g}$$

E = corrected sensitivity

E_c = 11.5 Rms mv/peak g (sensitivity)

C_p = 9725 uuf (accelerometer element capacitance)

C_c = 300 uuf (external capacitance)

C_t = 155 uuf (cable capacitance) + 20 uuf (filter cap.)

$$E = 11.5 \frac{(9725 + 300)}{(9725 + 175)} = (11.5) \frac{(10,025)}{9900}$$

$$E = 11.61 \text{ Rms mv/peak g}$$

or dividing by .707

$$E = 16.3 \text{ mv/peak g}$$

The "g" level for a particular voltage as seen on the scope is calculated as follows:

For the 1.5^{lbs} load at one inch the voltage obtained was .4 volts or 400 mv.
Therefore the "g" level =
$$\frac{400 \text{ mv}}{16.3 \text{ mv/peak g}} = 24.6 \text{ g's}$$

IV. Recommendations:

The following are suggestions for the future use of the High Impact Shock Machine:

1. A new design on the carriage assembly is strongly recommended. The present design of the carriage is the limiting factor in efficient results. The carriage now rides down the guide rods but has enough lateral movement so that the carriage fails to hit the anvil at the same point on every drop. A possible solution to this problem would be to incorporate in the carriage a linear ballbearing type of guiding system. This would increase the probability of the carriage striking the anvil at the same point and would still permit the necessary free fall of the carriage.
2. In order for the shock impulses to be seen and photographed, it was necessary to incorporate a triggering switch. This switch triggered the trace on the oscilloscope just before impact of the carriage. Because the triggering mechanism had to be adjusted with every change of height, obtaining pulse traces in the center of the scope was impossible. A suggestion, therefore, would be to include a micro-switch in the triggering circuit as shown in Figure 1.
3. The entire machine vibrates, to some degree, after each drop of the carriage. Allow this vibration to stop before dropping the carriage again (placing the hand on the machine will serve this purpose). This procedure will alleviate any possibility of the machine's vibration interfering with the shock impulses.

V. Conclusions:

1. The best result, as indicated by the calibration curves, was given by the 5^{lb} test load. The 1.5^{lb} load, however, verified the calibration curve to the 6 inch level. After that point approximately the same "g" level was achieved at 8 inches and 10 inches. It is concluded that the terminal velocity for the 1.5^{lb} test load was reached at this height. The maximum "g" level, therefore, for the 1.5^{lb} test load is 74. The letters on the calibration curves correspond to the lettered pictures of the shock impulses.

2. For a number of mechanical problems (Part IV of this report) a true shock impulse cannot be obtained on every drop. It may be necessary to drop the carriage a number of times before a representative pulse is obtained.

3. Additional instructions to manufacturer's instructions per Appendix A.

CALIBRATION CURVE

TABLE LOAD - 1.5 lbs

PULSE DURATION - 8.0 ms. $\pm$ 1 ms

SHOCK IMPULSES FOR TABLE LOAD OF 1.5 lbs

I. DROP HEIGHT - 1" ; .2 volts/cm; 5 ms/cm

(a) DURATION - 7 ms; 400 mv; 24.6 g's

(b) DURATION - 7 ms; 400 mv; 24.6 g's

II. DROP HEIGHT - 2.5" ; .5 volts/cm; 5 ms/cm

(c) DURATION - 9 ms; 750 mv; 46 g's

(d) DURATION - 8.5 ms; 850 mv; 52 g's

SHOCK IMPULSES FOR TABLE LOAD OF 1.5 lbs

III. DROP HEIGHT - 4.5" ; .5 volts/cm; 5 ms/cm

(e) DURATION - 9 ms; 1000 mv; 61 g' s

(f) DURATION - 9 ms; 1100 mv; 67.5 g' s

IV. DROP HEIGHT - 5.8 ; .5 volts/cm; 5 ms/cm

(g) DURATION - 8.5 ms; 1100 mv; 67.5 g' s

(h) DURATION - 8 ms; 1200 mv; 74 g' s

SHOCK IMPULSES FOR TABLE LOAD OF 1.5^{lbs}

V. DROP HEIGHT - 8" ; .5 volts/cm; 5 ms/cm

(i) DURATION - 8.5 ms; 1100 mv; 67.5 g's

(j) DURATION - 8.5 ms; 1150 mv; 71 g's

VI. DROP HEIGHT - 10" ; .5 volts/cm; 5 ms/cm

(k) DURATION - 7.5 ms; 1000 mv; 61 g's

(l) DURATION - 8 ms; 1100 mv; 67.5 g's

Astronuclear
Laboratory

WANL-TMI-1753

CALIBRATION CURVE

TABLE LOAD - 5 lbs

PULSE DURATION - $8.5 \text{ ms} \pm 1 \text{ ms}$

SHOCK IMPULSES FOR TABLE LOAD OF 5 lbs

I. DROP HEIGHT - 1" ; .5 volts/cm; 5 ms/cm

(a) DURATION - 7 ms; 490 mv; 30 g's

(b) DURATION - 7 ms; 500 mv; 30.6 g's

II. DROP HEIGHT - 4" ; .5 volts/cm; 5 ms/cm

(c) DURATION - 8.0 ms; 850 mv; 52 g's

(d) DURATION - 8.0 ms; 1000 mv; 61 g's

SHOCK IMPULSES FOR TABLE LOAD OF 5¹bs

III. DROP HEIGHT - 6" ; .5 volts/cm; 5 ms/cm

(e) DURATION - 8.5 ms; 1100 mv; 67.5 g's

(f) DURATION - 7.5 ms; 1200 mv; 74 g's

IV. DROP HEIGHT - 9.7" ; .5 volts/cm; 5 ms/cm

(g) DURATION - 11 ms; 1500 mv; 92 g's

(h) DURATION - 11 ms; 1500 mv; 92 g's

FIGURE 1 - SHOCK MEASUREMENT SETUP WITH
TRIGGERING SWITCH

MATERIAL - CARBON STEEL

FIGURE 2

DRILL 1/2" HOLES IN ANGLES
AND BASE PLATE AS
SHOWN
12 HOLES TOTAL REQ'D

SHOCK MACHINE
BASE PLATE

J. MENDICINO
11/22/66

THIS FACE MUST BE
FLAT AFTER WELDING

TYPICAL
4 REQ'D

TYPICAL
4 REQ'D

7/32 DIA
pilot hole
for 1/4" Dowel pin
4 REQ'D

APPENDIX A

ECON - O - SHOK

I N S T R U C T I O N M A N U A L

HIGH IMPACT SHOCK MACHINE

Models

SH-5

SH-2

Associated Testing Laboratories, Inc.

Wayne, New Jersey

ASSOCIATED TESTING LABORATORIES, INC.

MANUFACTURING DIVISION

I N S T R U C T I O N M A N U A L

A. Installation

1. Mechanical

a. Model SH-2

The unit should be mounted on a level concrete floor or reinforced concrete base so that its full weight can be supported. All greased surfaces should be wiped clean with kerosene, or similar solvent, and coated with light weight machine oil prior to operation.

b. Model SH-5

The unit should be positioned and fastened to a level concrete floor or sub-base utilizing "J" bolts or brackets to prevent movement during testing. All greased surfaces should be wiped clean with kerosene, or similar solvent, and coated with light weight machine oil prior to operation. Finally, when installing the spring on the base of the machine, care should be exercised to insure against over-tightening the mounting bolts. As a general rule, no more than 1 to 2 foot-pounds of torque should be applied to these bolts.

B. Operation

Accelerometer

Low Pass
Filter

Oscilloscope

Shock
Machine

Trigger
Circuit

Block Diagram Illustrating Basic Instrumentation

- a. Securely mount the part to be tested on the platform, using #10-32 bolts in as many locations as possible. Do not exceed the rated capacities. For lighter parts, add sufficient additional weight to total the specified loads corresponding to the "G" range desired. (see calibration curves). Distribute the weight so its center of gravity is near the center of the platform, if possible.
- b. Mount an accelerometer on the fixture, close to a fastening bolt, and connect it to the low pass filter input.
- c. Disengage rebound arrester, located on the right or left hand side of the platform, by compressing the spring loaded

collar and affixing the trigger lever in place. This device will insure a single impact and prevent the head from rebounding after the initial shock.

- d. Set the lower cut-off frequency of the filter to its minimum value (0.2 CPS or lower) and set the upper cut-off frequency to value computed as shown on page 3.
- e. Connect the output of the filter to the vertical input terminals of the oscilloscope.
- f. Set oscilloscope controls and calibrate system as follows:

Scope: This procedure is intended to outline the method to be used in calibrating this shock machine. The method is limited to those machines which develop shock impulses by virtue of dropping a specimen mounting carriage onto some kind of impact arresting material. The developed shock impulse will approximate a half-sine wave.

Equipment required:

1. Piezoelectric Accelerometer (Endevco Model 2215)
2. Band Pass Filter (Krohn-Hite Model 330-M)
3. Cathode Ray Oscilloscope (HP Model 130A)
4. Individual unit instruction books.

Method: 1. Connect the test equipment as shown in the following diagram:

2. Using one of the two methods described below, calibrate the entire system so that the oscilloscope will present a dimensionally convenient picture of impulse amplitude (for instance, 100 g/major vertical division).

System calibration can be performed using a combination of signal synthesis and mathematical computation. The first step involves the computation of the actual accelerometer sensitivity which is affected by the total amount of capacity external to the accelerometer element. The formula for computation of actual sensitivity is

as follows:

CALIBRATION PROCEDURE

$$\Gamma = E_c \left(\frac{C_p + C_c}{C_p + C_t} \right) \quad \text{RMS mv/peak g}$$

Where: E = Corrected sensitivity

E_c = Factory supplied calibration in RMS mv/peak g

C_p = Accel. element capacitance

C_c = External capacitance with which E_c was determined

C_t = Total external circuit capacitance (cable and Filter input)

For example: E_c = 4.75 RMS mv/peak g

C_p = 6650 uuf C_c = 300 uuf

C_t = 317 uuf + 20 uuf = 337 uuf

$$E = 4.75 \left(\frac{6650 + 300}{6650 + 337} \right) = 4.72 \text{ RMS mv/peak g}$$

Using a signal generator tuned to an appropriate frequency, a known voltage equivalent to some multiple of the computed calibration factor is applied to the input terminals of the Band Pass Filter and the oscilloscope vertical gain controls are set to present a dimensionally convenient picture of impulse amplitude. For instance, using the example above, assume that the presentation desired is 10 peak g per major vertical division. A signal voltage of 47.2 mv RMS is applied to the Band Pass Filter input terminals and the oscilloscope gain controls are set so that one-half of a complete sine wave deflects the scope trace exactly one major vertical division. The frequency at which this operation is performed is dependent on the time duration of the anticipated shock impulse. For instance, if the expected time duration is 11 ± 1 milliseconds for a half-sinusoidal shock impulse, the period of a full sine wave would be 22 ± 2 milliseconds.

The frequency of the signal generator should be computed from the following formula:

$$f = \frac{1}{T} = \frac{1}{22 \pm 2 \text{ MS}} = 50 \text{ cps to } 41.5 \text{ cps}$$

The pass band of the Band Pass Filter should be set to give the minimum low frequency cutoff permitted by the controls of the filter (for the Krohn-Hite Model 330-M, this frequency is 0.2 cps) and the high frequency cutoff should be set for at least twice the computed generator frequency (in this instance, 100 cps), or greater. A diagram of the calibration set-up is shown below:

3. Drop the table from various heights using each device or set-up which controls time duration of shock impulse. The number of heights should be sufficient to give an adequate number of points for plotting a series of curves with peak acceleration as the ordinate and drop height as the abscissa. Time duration of shock impulse would then be the constant for each curve.
4. For best service and repeatability, remove foreign matter which may have accumulated on the guide rods and on the anvil, and service release mechanism to insure proper function of the machine components. In addition, the guide rods should be coated frequently with very light machine oil.
5. Raise table to proper height corresponding to "G" level desired and release.

NOTE: The machine should be periodically calibrated utilizing the outlined procedure, noting that the approximate calibration curves (attached to this manual) are based on the table loads indicated thereon, together with individual spring sizes. For best calibration results, these boundary conditions should be closely observed.

C. Parts and Service

The Service Department of Associated Testing Laboratories is prepared to handle field service work in a prompt and efficient manner. When requesting service, please furnish the serial number of the equipment

and state the exact nature of the trouble. As a further service to our customers, the Manufacturing Division maintains a large stock of spare parts. Where design modifications or improvements change the part specification, the up-to-date equipment can be furnished. Generally, parts are shipped from stock within one day of receipt of the order. Please list the serial number of the equipment and description of the required part.

ASSOCIATED TESTING LABORATORIES, INC.
Wayne, New Jersey

2/15/63

Form 33

ASSOCIATED TESTING LABORATORIES, INC.

2/15/63

Form 33

ASSOCIATED TESTING LABORATORIES, INC.

ASSOCIATED TESTING LABORATORIES, INC.

APPENDIX B

MIL-STD-202C
12 September 1963

METHOD 202B

SHOCK

(SPECIMENS WEIGHING NOT MORE THAN 4 POUNDS)

1. PURPOSE. The shock test is intended to determine the suitability of small parts, with or without auxiliary protection, for use in electronic equipment which may be subjected to moderately severe shocks as a result of suddenly applied forces or abrupt changes in motion produced by rough handling, transportation, or field operation. Shocks of this type may disturb operating characteristics or cause damage similar to that resulting from excessive vibration, particularly if the shock pulses are repetitive. The apparatus employed in this test was originally designed for shock testing of electrical-indicating instruments and its use was later extended to other small parts. This device provides a standard laboratory means of creating reproducible shocks of moderate severity such as parts might experience when equipment is dropped on a hard surface or bounced in a vehicle. The apparatus does not duplicate the magnitude-time duration relationship of all kinds of shock pulses experienced in field service; test performed with it have proved reasonably adequate for evaluation purposes and for providing data for the design of protective and corrective measures. The basic pulse duration of this test machine as used in most component specifications is about 7 milliseconds, which is virtually independent of drop height, but which does vary somewhat with component weight. These variations are too small to affect reproducibility.

2. APPARATUS. The shock-testing apparatus specified herein and shown on figures 202-1 to 202-6 inclusive, shall be used. The main structure consists of a cast-iron base to which upright channels are securely bolted. The tops of the upright channels are secured to a top channel which also supports rods to guide the movable carriage assembly. The other ends of the guide rods are screwed into the base. The carriage assembly carries on its under side a stiff

calibrated spring resiliently mounted but at the same time having helical compression springs sufficiently strong to hold the calibrated spring in contact with the effective cylindrical bearings.

2.1 BASE. The cast-iron base shall be a single piece constructed so that it has no practical yielding.

2.2 MOVABLE CARRIAGE ASSEMBLY. The prime requisite in the construction of the movable carriage assembly is rigidity. For this reason 1/4-inch-thick steel shall be used. After being securely fastened together with screws, the carriage parts shall be welded so as to give the equivalent of single-piece construction.

2.3 MOUNTING ACCESSORIES. Mounting accessories which will assure rigid fastening of the specimens to the carriage assembly shall be used. Since special tests may require special mounting fixtures, the carriage test plate shall be provided with a number of extra holes. The top of the carriage frame shall be provided with a hoding bolt to facilitate the rigid clamping necessary.

2.4 STATIONARY ANVIL. The stationary anvil shall be made of hardened tool steel with a radius of curvature of 1 1/2 inches and shall be bolted tightly to the base.

2.5 CALIBRATED SPRING. The calibrated spring shall be made of first-quality carbon tool steel, spring-tempered, and having a hardness of 85 to 95, Rockwell B scale. It shall be annealed and ground flat stock of the following composition:

	Percent
Carbon	1.08 to 1.18
Chromium	0.40 to 0.50
Manganese	.20 to .30
Silicon	.20 to .30
Phosphorus and sulfur.....	.025 maximum

The spring shall be 1 3/4 inches wide and approximately 0.150 inch thick, and shall have an over-

- 32 -

FIG. 1

FIG. 2

9/32 DIA 7 HOLES

8-32 NC-2B 2 HOLES

1/8-32 NC-2B 2 HOLES

32 1/2

31 1/4

23

10

6 1/2

4

2

2 1/2

1 3/4

3/4

3/16

1/8

1/16

1/32

1/64

1/128

1/256

1/512

1/1024

1/2048

1/4096

1/8192

1/16384

1/32768

1/65536

1/131072

1/262144

1/524288

1/1048576

1/2097152

1/4194304

1/8388608

1/16777216

1/33554432

1/67108864

1/134217728

1/268435456

1/536870912

1/1073741824

1/2147483648

1/4294967296

1/8589934592

1/17179869184

1/34359738368

1/68719476736

1/137438953472

1/274877906944

1/549755813888

1/1099511627776

1/2199023255552

1/4398046511104

1/8796093022208

1/17592186044416

1/35184372088832

1/70368744177664

1/140737488355328

1/281474976710656

1/562949953421312

1/1125899906842624

1/2251799813685248

1/4503599627370496

1/9007199254740992

1/18014398509481984

1/36028797018963968

1/72057594037927936

1/144115188075855872

1/288230376151711744

1/576460752303423488

1/1152921504606846976

1/2305843009213693952

1/4611686018427387904

1/9223372036854775808

1/18446744073709551616

1/36893488147419103232

1/73786976294838206464

1/147573952589676412928

1/295147905179352825856

1/590295810358705651712

1/1180591620717411303424

1/2361183241434822606848

1/4722366482869645213696

1/9444732965739290427392

1/18889465931478580854784

1/37778931862957161709568

1/75557863725914323419136

1/151115727451828646838272

1/302231454903657293676544

1/604462909807314587353088

1/1208925819614629174706176

1/2417851639229258349412352

1/4835703278458516698824704

1/9671406556917033397649408

1/19342813113834066795298816

1/38685626227668133590597632

1/77371252455336267181195264

1/154742504910672534362390528

1/309485009821345068724781056

1/618970019642690137449562112

1/1237940039285380274899124224

1/2475880078570760549798248448

1/4951760157141521099596496896

1/9903520314283042199192993792

1/19807040628566084398385987584

1/39614081257132168796771975168

1/79228162514264337593543950336

1/158456325028528675187087900672

1/316912650057057350374175801344

1/633825300114114700748351602688

1/1267650600228229401496703205376

1/2535301200456458802993406410752

1/5070602400912917605986812821504

1/10141204801825835211973625643008

1/20282409603651670423947251286016

1/40564819207303340847894502572032

1/81129638414606681695789005144064

1/162259276829213363391578010288128

1/324518553658426726783156020576256

1/649037107316853453566312041152512

1/1298074214633706907132624082305024

1/2596148429267413814265248164610048

1/5192296858534827628530496329220096

1/10384593717069655257060992658440192

1/20769187434139310514121985316880384

1/41538374868278621028243970633760768

1/83076749736557242056487941267521536

1/166153499473114484112975882535043072

1/332306998946228968225951765070086144

1/664613997892457936451903530140172288

1/1329227995784915872903807060280344576

1/2658455991569831745807614120560689152

1/5316911983139663491615228241121378304

1/10633823966279326983230456482242756608

1/21267647932558653966460912964485513216

1/42535295865117307932921825928971026432

1/85070591730234615865843651857942052864

1/170141183460469231731687303715884105728

1/340282366920938463463374607431768211456

1/680564733841876926926749214863536422912

1/1361129467683753853853498429727072845824

1/2722258935367507707706996859454145691648

1/54445178707350154154139937189082913832

FIGURE 202-2. Main frame details (see fig. 202-5 for notes and bill of materials).

④ GUIDE ROD
STEEL
2 REQD

⑤ TOP CHANNEL
STEEL-HOT ROLLED
1 REQD

⑥ ANVIL
TOOL STEEL-HARDEN & DRAW 60-62
ROCKWELL C
1 REQD

⑦ TOP ANGLE
STEEL-HOT ROLLED
2 REQD

FIGURE 202-2—Continued

METHOD 202B
12 September 1963

8 BASE
CAST IRON-NORMALIZE
I REQD

FIGURE 202-3. Carriage-assembly and base details (see fig. 202-5 for notes and bill of materials)

MIL-STD-202C
12 September 1963

METHOD 202B
12 September 1963

Item No. or MS part No.	Description	Quantity
1	Left-side channel.....	1
2	Right-side channel.....	1
3	Scale.....	1
4	Guide rod.....	2
5	Top channel.....	1
6	Anvil.....	1
7	Top angle.....	2
8	Base.....	1
9	Carriage frame.....	1
10	Test plate.....	1
11	Brace.....	2
12	Side plate.....	2
13	Pointer.....	1
14	Spring, calibrated.....	1
15	Pivot.....	2
16	Spring, compression.....	2
17	Squarehead bolt, # 1/4-28 UNF-2A x 2 long, steel, modified.....	1
18	Acorn nut, # 1/4-20 UNC-2B, steel.....	2
19	Hexagon nut, # 1/4-20 UNC-2B, steel.....	14
20	Flat washer, 1/4, steel.....	4
21	Stop nut, per note 5.....	2
MS35221-42	Screw.....	2
MS35221-44	Screw.....	16
MS35237-51	Screw.....	4
MS35295-6	Bolt.....	20
MS35295-7	Bolt.....	4
MS35295-12	Bolt.....	2
MS35338-4	Lockwasher.....	2
MS35338-6	Lockwasher.....	26

1. All dimensions in inches.
2. Unless otherwise specified, tolerances are $\pm 1/64$ on fractions, $\pm .005$ on decimals, and $\pm 1/4^\circ$ on angles.
3. Finish: The general assembly and the carriage shall be given a light spray coat of metal primer and then finished with a full spray coat of lusterless gray enamel. The mounting fixtures shall be cadmium- or nickel-plated. The spring, part 14, anvil, part 6, and pivots, part 15, shall be flash-dip nicked.
4. Develop thickness experimentally so that spring constant will be 5,000 to 5,500 pounds-per-inch deflection when hardened and drawn.
5. Stop nut shall be catalog No. 29U040, as made by Elastic Stop Nut Corporation, Union, N. J., or equal.
6. The materials specified herein have been found satisfactory, but any suitable material may be used.
7. Scale shall be graduated in tenths of an inch. Fill black.

FIGURE 202-5. Notes and bill of materials.

FIGURE 202-6. Typical calibration curves.

all length of 7½ inches. The approximate spring constant (K) shall be between 5,000 and 5,500 pounds-per-inch deflection.

3. CALIBRATION. The actual calibration shall be made on the completely assembled machine. Static loads up to 500 pounds shall be applied to the top of the carriage frame, and the spring deflections measured by means of a dial gage or height gage. The gage shall be mounted on the top surface of the cast-iron base as one reference surface, and measurements shall be taken at the center of the carriage test plate. The

$$\text{Spring constant (K)} = \frac{\text{load in pounds}}{\text{inches deflection}}$$

For a spring constant of 5,000, the deflection for a 500-pound load would be 0.100 inch.

3.1 CALIBRATION CURVES. Use of the shock-testing mechanism is facilitated by plotting calibration curves for various weights of specimens. Ordinarily, parallel curves for specimen weights of 0.5 pounds and 2.0 pounds will be adequate, and intermediate weights can be estimated. Figure 202-6 shows such curves arbitrarily calculated on the basis of a mean spring constant (K) of 5,250 and a total carriage-and-mounting-fixture weight of 9¾ pounds.

3.2 COMPUTATION OF ACCELERATION (G.) The following formula for obtaining the required acceleration or shock, in terms of gravity units (G), is utilized for variations of component weight and spring constant (K):

$$G = \sqrt{\frac{2hK}{w}}$$

(When G is specified, the necessary height may be determined from:)

$$h = \frac{G^2 W}{2k}$$

Where:

G = nominal value of acceleration (gravity units).

h = height from which carriage is dropped (inches).

K = spring constant (pounds-per-inch deflection).

w = weight of carriage and its test load (pounds).

4. PROCEDURE. The shock-testing apparatus shall be mounted on a sturdy laboratory table or equivalent base and leveled before use. The specimen shall be rigidly mounted on the carriage. For each blow, the carriage shall be raised to the height necessary for obtaining the required acceleration and then allowed to fall. Means shall be provided to prevent the carriage from striking the anvil a second time. The mounting method, the required acceleration, the number of blows, and the electrical-load conditions, if applicable, shall be as specified.

5. MEASUREMENTS. Upon completion of the required number of blows, measurements shall be made as specified.

6. SUMMARY. The following details must be specified in the individual specifications:

- (a) Mounting method and accessories (see 2.3 and 4).
- (b) Acceleration requirements (see 4).
- (c) Number of blows (see 4).
- (d) Electrical-load conditions, if applicable (see 4).
- (e) Measurements after shock (see 5).