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10-19-98
W Layne
10/27/98
RBCraner

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T-3-2
Case No. 693.00
Ref. Sym: 1611 (315)
Project No. ET-2746-C
Completed 12/9/55

TO: DISTRIBUTION

Re: Final Report on Vibration and Shock Investigation of Canned Capsules

Object of Test

The object of this test was to complete the previously begun study of the effects of vibration and shock on canned dummy capsules.

Procedure and Results

Three specimens, etched 55-1, 55-2-TU, and 55-3-TU respectively, each weighing approximately 45 pounds, were the first subjected to vibration. Capsules 55-1 and 55-2-TU were mounted in a cantilevered position on either side of a jig so that the direction of vibration was along a diameter of the support cylinder.

A resonance survey with one g acceleration to the table was performed which required 35 minutes to complete. The acceleration in each of three mutually perpendicular directions for each specimen was monitored through the use of crystal accelerometers. The response of both capsules was similar, so the results of the resonance survey shown in Fig. 1 are typical, although only the accelerations recorded for 55-1 are plotted.

As shown in Fig. 1, the table input was amplified over 11 times in the vertical direction at resonance. The accelerometers were mounted in a group at the equatorial weld, and as the specimen made its long excursion vertically, the accelerometer measuring movement in a direction perpendicular to the face of the jig recorded almost 7 g. This, of course, is largely a result of the structure (welds, support cone, and E-1 ring) flexing, and acting in effect as a pivot, so that a considerable accelerative component exists in this horizontal direction. As shown, the motion in the third direction was less than one third this value.

After the resonance survey, vibration at resonance with a 2 g input to the table was begun. The resonant point was found to have shifted slightly, the greatest amplification occurring at 146 cps. At this frequency, 30.3 g acceleration in the vertical direction was recorded on 55-1. After approximately 7 minutes at resonance, the spot welds on the grooved sleeve of one of the specimens gave way. This sleeve was welded to the support cylinder in 16 spots.

The capsule etched with the markings 55-3-TU was used to replace the broken specimen. The sleeve of this specimen was secured to the support cylinder by 24 spot welds, which began to break after 5 minutes of vibration at resonance.

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PERSON CHANGING MARKING & DATE: W C Layne 10/28/98 — RECORD ID: 99SN0153
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The undamaged specimen survived 35 minutes of resonance survey at one g and vibration at resonance (with two g input to the table) for a total of 12 minutes. The sleeve of this capsule was secured to the support cylinder by 32 spot welds.

Two 31-pound capsules, marked 110-1-TU and 110-2-TU, were next mounted as cantilevers. One cycle of vibration with 2 g input to the table from 60-500-60 cps was performed with no apparent damage to either specimen. Resonance seemed to be between 170 and 180 cps.

Another vibrational cycle, with a table displacement of 0.010 inch from 55 to 100 cps and constant acceleration of 5 g from 100-500-100 cps, disclosed that the resonance frequency was lowering. Since this is usually indicative of breakage, either imminent or accomplished, a survey from 125 to 250 cps with a 2 g input to the table was performed which substantiated the shift in resonance frequency.

When 110-1-TU was removed from the jig, it was noted that the E-1 ring was battered and scarred and that the sleeve on the supporting cylinder was galled on the surface which mated with the flange of the jig. This damage was probably caused by a slight warpage of the sleeve which occurred during the Heli Arc welding process. The capsule, however, had withstood about 21 minutes of vibration with no actual breakage resulting.

The damaged specimen was replaced with 110-4-TU, and vibration begun with 0.010 inch displacement 55-100-55 cps, 5 g from 100-500-100 cps. The weld making the union of the flared or cupped end of the supporting cylinder with the case of the capsule of 110-4-TU broke near 160 cps of the first vibrational cycle, so it was retired from the test.

The consultant obtained the 110 mock-up which had been a component in the recent "fly-around" test performed on the Betty. Since 110-2-TU seemed to be undamaged by vibration, the 110 mock-up was mounted as a cantilever opposite this specimen.

A resonance survey requiring 20 minutes was performed with a one g input to the table. The recorded accelerations experienced by the 110 mock-up are shown in Fig. 2. This resonance curve is extended only far enough to show the isolation which occurs above the resonance frequency. Following the resonance survey one 11-minute cycle with a 2 g input to the table with no apparent damage resulting was performed. With the 2 g input the vertical acceleration of the capsule was 36 g at resonance.

After some 12 minutes of cycling the E-1 ring on the mock-up from the Betty broke. Also, during vibration a setscrew retaining the ball to the stub cone worked out, but no rotation occurred. The only visible damage to the mock-up itself was some marring of the stub cone where it contacted the jig.

As for 110-2-TU, no damage was apparent after the specimen had endured nearly an hour of vibration, so it was retained and paired on the jig with 110-3-TU. This combination was vibrated at resonance for 25 minutes. The resonance frequency drifted downward from 161 to 125 cps in this time, so the table was shut down

and the specimens inspected. This examination disclosed that a crack had formed in a burned portion of the Heli Arc weld at the junction of the flared top of the supporting cylinder and the encasement of the ball of 110-3-TU. Approximately 80 minutes of vibration resulted in no visible damage to 110-2-TU.

Ten 200 specimens, weighing approximately 60 pounds each, were next made available for test. Of this number only those with the seemingly better welds were selected.

Two capsules, marked 200-4-TU and 200-9-TU, were mounted as cantilevers and a resonance survey conducted with a 2 g input to the table. The results of this survey are shown in Fig. 3. The true resonance at 125 cps was not discovered during the survey, so the magnification factor shown by the dotted lines is the value found while vibrating at resonance with a 1 g input to the table. Both specimens survived the survey and vibration at resonance with a 1 g input for 30 minutes with no visible damage. However, with a 2 g input, the resonance frequency constantly reduced, indicating damage. After 30 minutes of vibration with this input, the specimens were removed and examined. A crack was found in the Heli Arc weld at the junction of the support cylinder with the ball of 200-9-TU. There was a possibility that the spot welds on the grooved sleeve of 200-4-TU had begun to break also, but the breaks, if any, had not become definite enough so that certitude was possible.

Two specimens marked 200-6-TU and 200-10-TU were next mounted as cantilevers, but the mounting jig failed before any definite findings could be made.

As soon as new jig adapters could be fabricated, the test was resumed. These fixtures were made of 4340 steel, roughly machined, heat treated to maximum resistance to flexing, then ground to dimensions.

The specimens marked 200-6-TU and 200-7-TU were mounted, and a rapid run made upward from 60 cps to find resonance. This was established at 122.5 cps, and was extremely sharp. The specimens were vibrated at this frequency for 30 minutes with a 3 g input to the table with no apparent damage.

With a 4 g input to the table, the frequency was increased from 60 to 90 cps. At this frequency the E-1 ring on 200-7-TU broke. It was replaced and the increase from 60 cps begun again with the same input to the table. The E-1 ring used as a replacement broke at 103 cps.

Inasmuch as the sleeve on 200-7-TU was somewhat scarred, this specimen was replaced by 200-1-TU, which had only 24 spot welds securing the grooved sleeve to the support cylinder.

Again, with a 4 g input to the table, the frequency was increased from 60 cps. The spot welds (24 in number) on 200-1-TU began to give way at 115 cps, following what seemed to be a sharp resonance between 85 and 90 cps.

The capsule (200-1-TU) with the broken spot welds was replaced by 200-5-TU. With a 4 g input to the table a sharp resonance was again noted at 85 cps. An

examination disclosed that one of the flanges on the grooved sleeve of 200-6-TU had begun to split off. It was further observed that several spot welds diametrically opposite this break had also given way.

The specimen marked 200-8-TU was used as a replacement for the broken unit. After approximately one minute at resonance with a 4 g input to the table, the Heli Arc weld connecting the ball of 200-5-TU with the flared end of the support cylinder broke around nearly 300° of arc.

Because of information already gained and merely being substantiated, high frequency vibration was stopped at this time.

Inasmuch as the consultant was interested in proof-loading with the equipment available at Los Alamos, 200-10-TU was mounted on the Sonntag so that vibration was along a diameter of the supporting cylinder. With a displacement of 0.061 inch, the specimen was vibrated at 55 cps (9.3 g) for 15 minutes with no damage accruing. The table double amplitude was then increased to 0.097 inch, which gives an acceleration of 15 g at 55 cps. After almost exactly 15 minutes of vibration at this acceleration, the E-1 ring split.

Following this 200-2-TU and 200-8-TU were mounted on the shock table in an orientation such that the direction of the inertial force would be along a diameter of the supporting cone. The specimens were then subject to successive impact loadings of 50 g for 11 milliseconds.

After the fourth such drop, all 24 of the spot welds securing the grooved sleeve of 200-2-TU to the support cylinder gave way. The cylinder slipped out of the sleeve, which was secured to the jig by the E-1 ring, and the ball and attached cylinder rolled free. It is possible that the spot welds had begun to give way before the fourth drop and had gone unnoticed in the superficial inspection made after each impact.

The remaining capsule seemed undamaged, so it was subjected to two additional shocks for a total of six. The sleeve of this unit was secured to the support cylinder by 32 spot welds. A close examination disclosed no sign of breakage in any of the welds.

Testing was curtailed at this time.

Conclusions and Recommendations

The series of tests performed has made several points apparent. Heli-Arc welding of the grooved sleeve to the supporting cylinder is difficult to perform satisfactorily because of the danger of burn through and/or the probability of warpage and consequent malfitting of the assembly. Spot welding is satisfactory for this position if a minimum of 32 spot welds are performed around the circumference.

Heli-Arc welding at the junction of the supporting cylinder and the ball is the

better process. However, this weld must be performed in an extremely careful manner to prevent burn through and to ensure proper positioning and metal flow.

As demonstrated by the high incidence of E-1 ring failures, the breaking of the grooved flange and two jig failures, these precautions should result in an assembly as sturdy as the means of securement and certainly as strong as the supporting structure.

The test has also demonstrated that proof-testing of the assembly is possible with low frequency vibration equipment.

Of course, actual acceleration resonance is the most pernicious condition, but the canned capsules will withstand even this for not inconsiderable periods if the assembly is well made.

R. G. Hamilton
Test Conducted by R. G. HAMILTON - 1611-2

M A Richter
Approved by M. A. RICHTER - 1611-2

RGH:1611-2:dr

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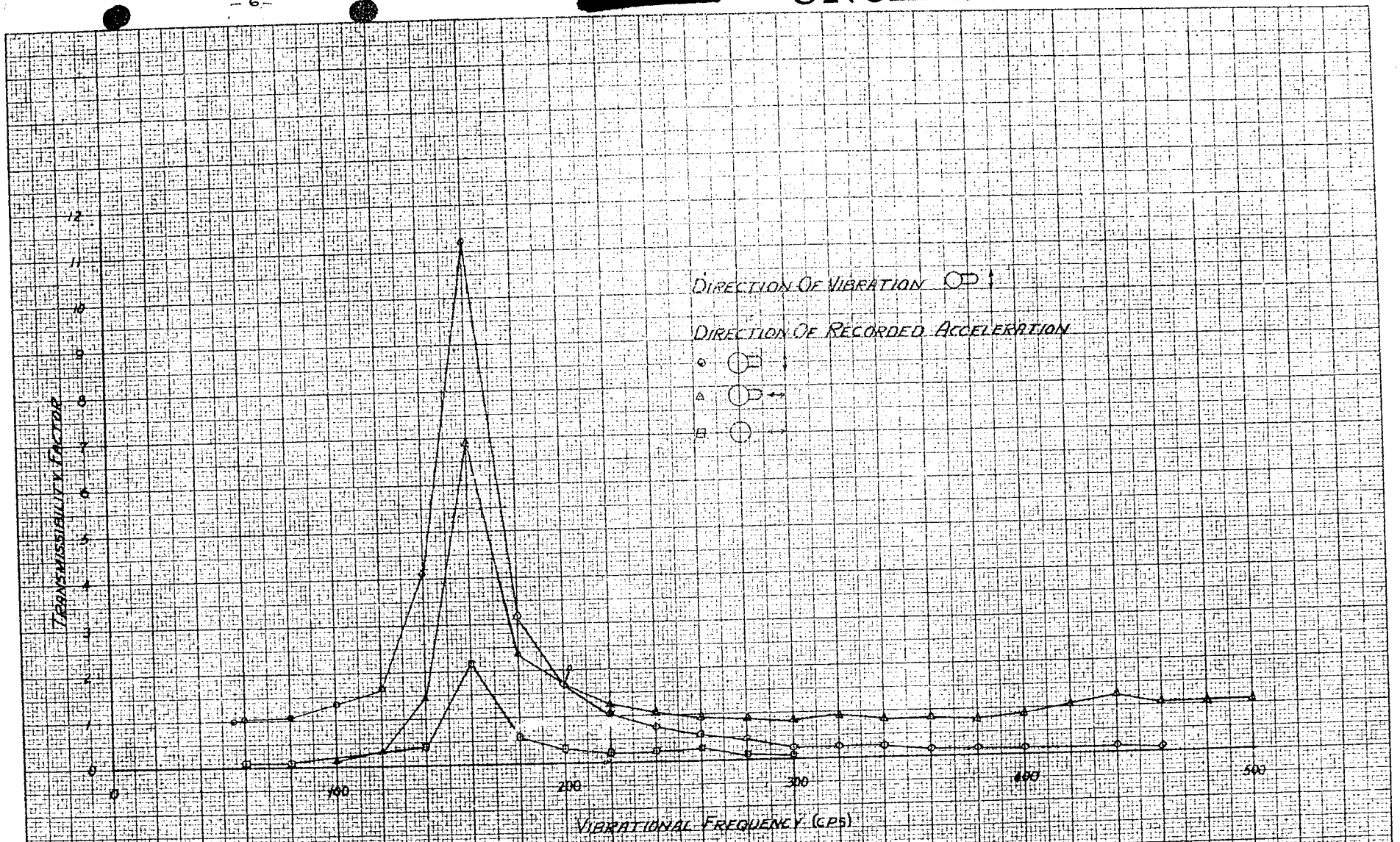

Fig 1 - Vibrational Response Of Canned Capsule 55-1
1G Input

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K+E 10 X 10 TO THE 1/2 INCH 359-11L KEUFFEL & ESSER CO. MADE IN U.S.A.

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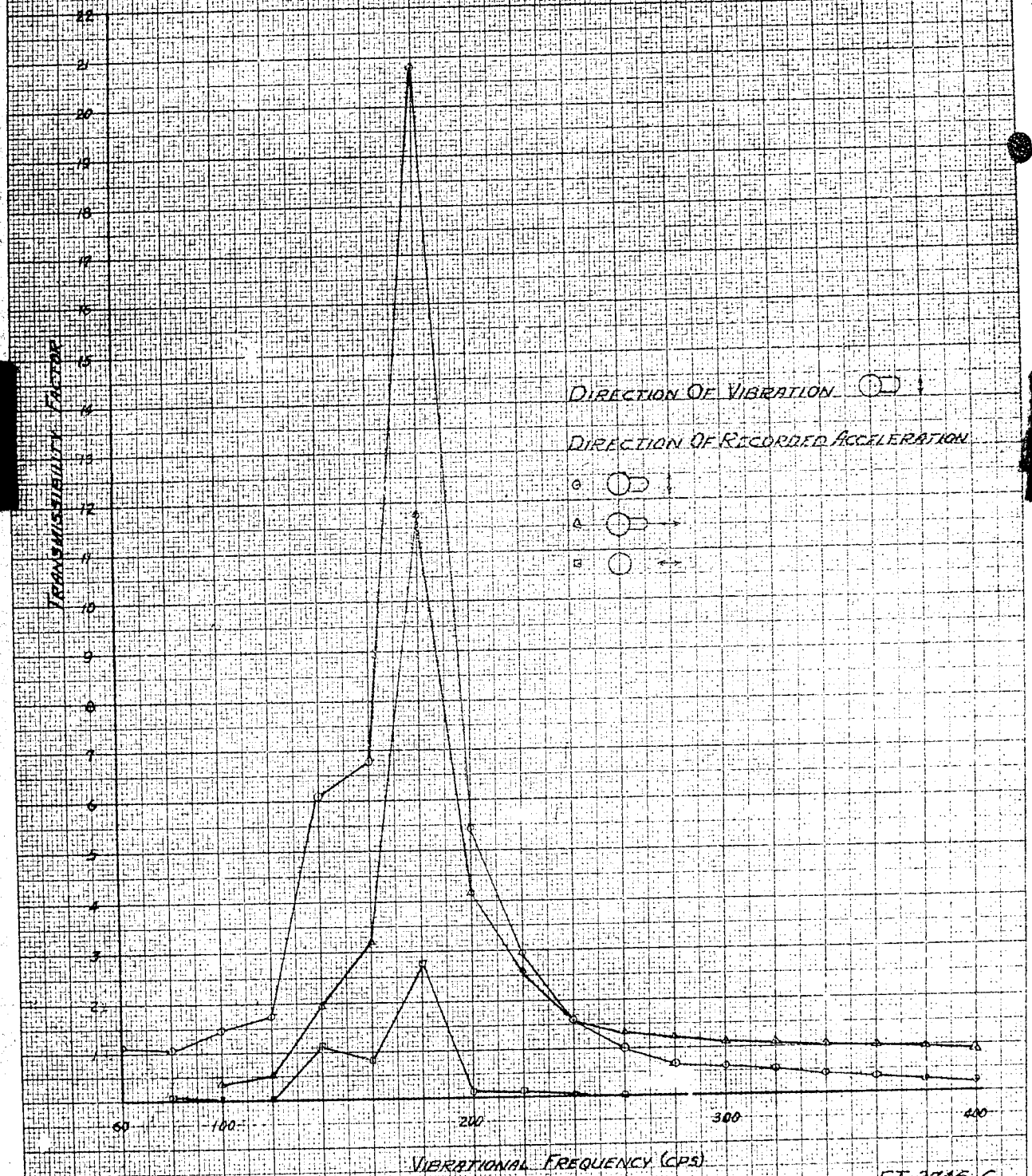

FIG 2 - VIBRATIONAL RESPONSE OF 110 MOCK UP
1G INPUT

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REF SYM 1611 ~~(309)~~ (315)

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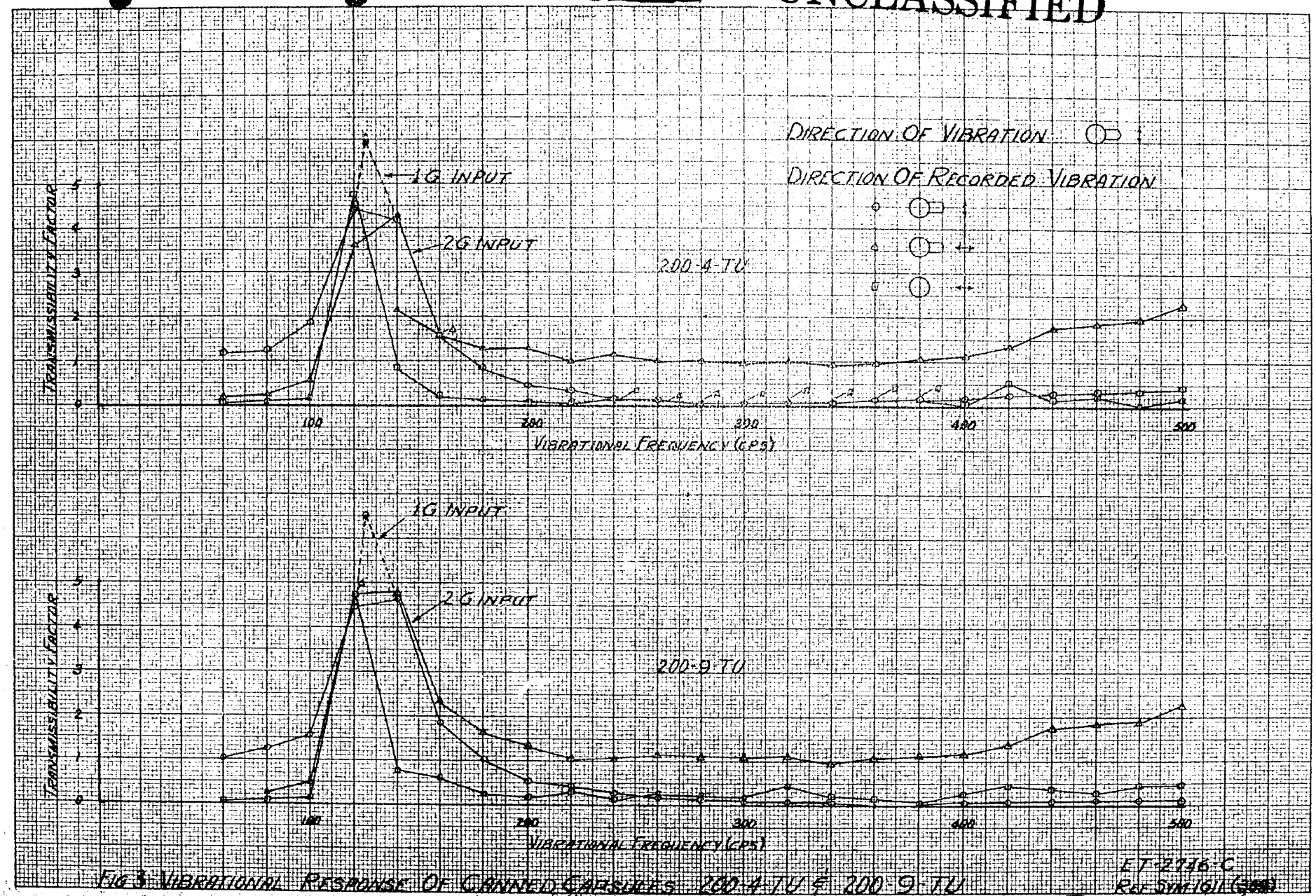

FIG 3 VIBRATIONAL RESPONSE OF CANNED CAPSULES 200-4-TU & 200-9-TU

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