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APPENDIX

CALCULATION OF VIBROMOTIVE FORCE

Theoretical Calculation

Vibromotive force is given theoretically in Eq. (6) as

$$F = 4mr\omega^2(A_2\cos 2\theta + A_4\cos 4\theta + - - - -)$$

For second mode vibromotive force, it becomes

$$F = 4mr\omega^2 A_2\cos 2\theta$$

Taking maximum value when $\cos 2\theta = 1$, it becomes

$$F = 4mr\omega^2 A_2 \qquad (24)$$

Substitute appropriate values of both engines in Eq.(24).

(a) For conventional engine

Mass of piston, piston rings, gudgeon pin and retainer		= 617	gm.
One third of connecting mass		= 626.5 ÷ 3 = 208,8333	gm.
	m	= 825.8333	gm.
Stroke		= 2.098	in.
	r	= 2.098 ÷2	in.
		= (2.098 ÷ 2) × 2.54	cm.
		= 2.6645	cm.
Length between centres of connecting rod,	l	= 4.325	in.
	p	= r/l = 0,2427	

$$A_2 = p + 1/4p^3 + 15/128p^5 + - - - - - \quad = 0.2462$$

Eq.(24) with above values becomes

$$F_{max} = 4 \times 825.8333 \times 2.6645 \times (2\pi\omega)^2 \times .2462 \div 3600 \qquad \text{gm-cm/sec}^2$$

$$= 23.7636\omega^2 \times 10^{5} \qquad \text{kg-m/sec}^2 \quad (25)$$

(b) For balanced engine

$$m = 815.83 \quad \text{gm}$$

$$r = 45 \quad \text{mm}$$

$$l = 166.15 \quad \text{mm}$$

$$p = 0.2709$$

$$A_2 = 0.276$$

Then, $F_{max} = 4 \times 815.83 \times 45 \times (2\pi\omega)^2 \times .276 \times 10^{6} \div 3600 \quad \text{kg-m/sec}^2$

$$= 44.45 \times 10^{5}\,\omega^2 \qquad \text{kg-m/sec}^2$$

Force produced by a pair of silent shafts in Eq.(21)

$$F_B = 8m_Br_B\omega^2\cos(2\theta + \alpha)$$

$$m_B = 1400 \quad \text{gm}$$

$$\alpha = \pi$$

$$r_B = 3.62 \quad \text{mm}$$

$$\cos(2\theta + \pi) = -\cos 2\theta = -1$$

$$F_B = 8 \times 1400 \times 3.62 \times (2\pi\omega)^2 \times (-1) \times 10^{6} \div 3600 \quad \text{kg-m/sec}^2$$

$$= -\,44.45 \times 10^{5}\omega^2 \qquad \text{kg-m/sec}^2$$

Thus $$F_{max} + F_B = 0$$

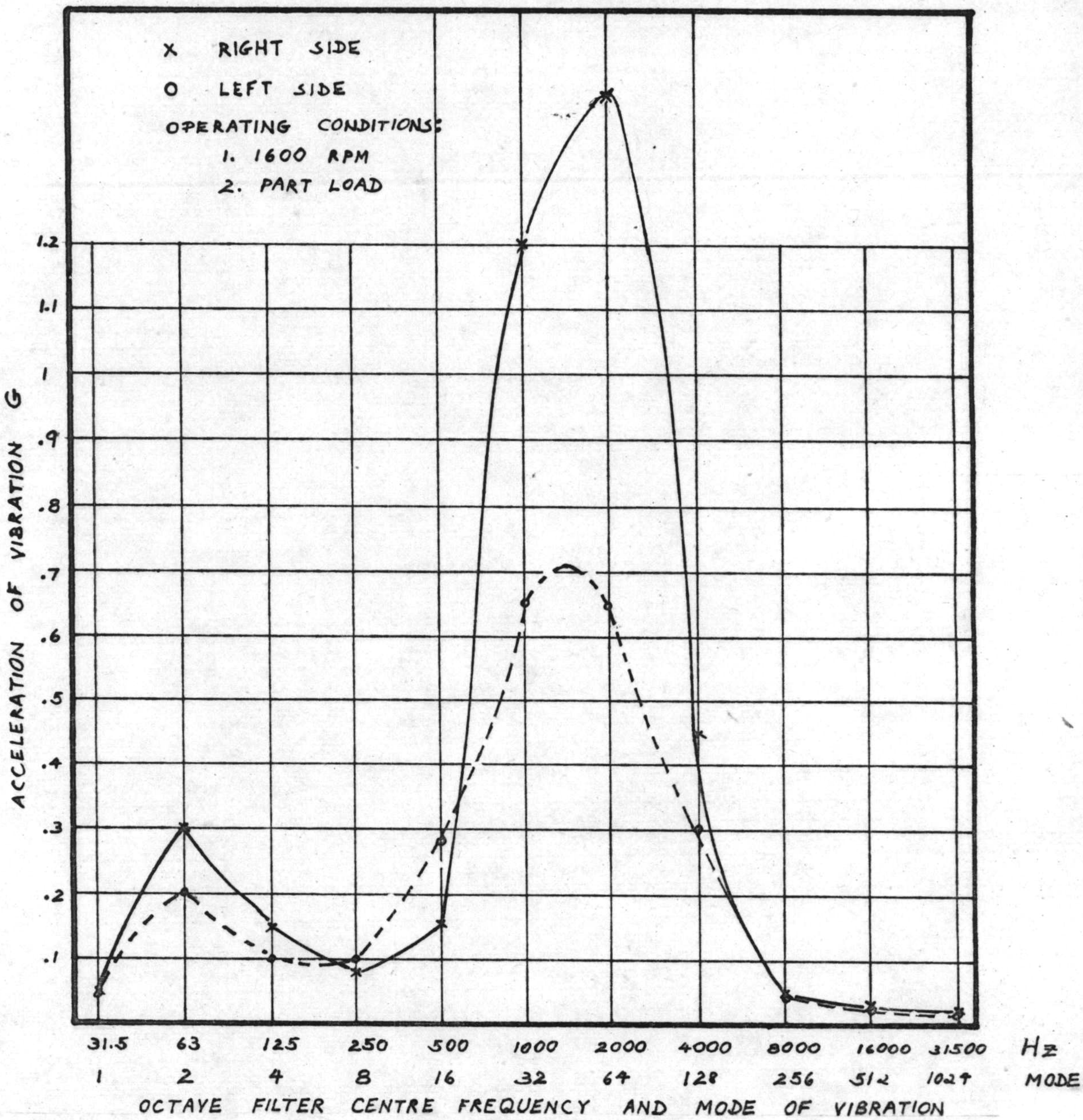

Fig.A-1 Acceleration of vibration plotted against mode of vibration at constant engine speed and part load

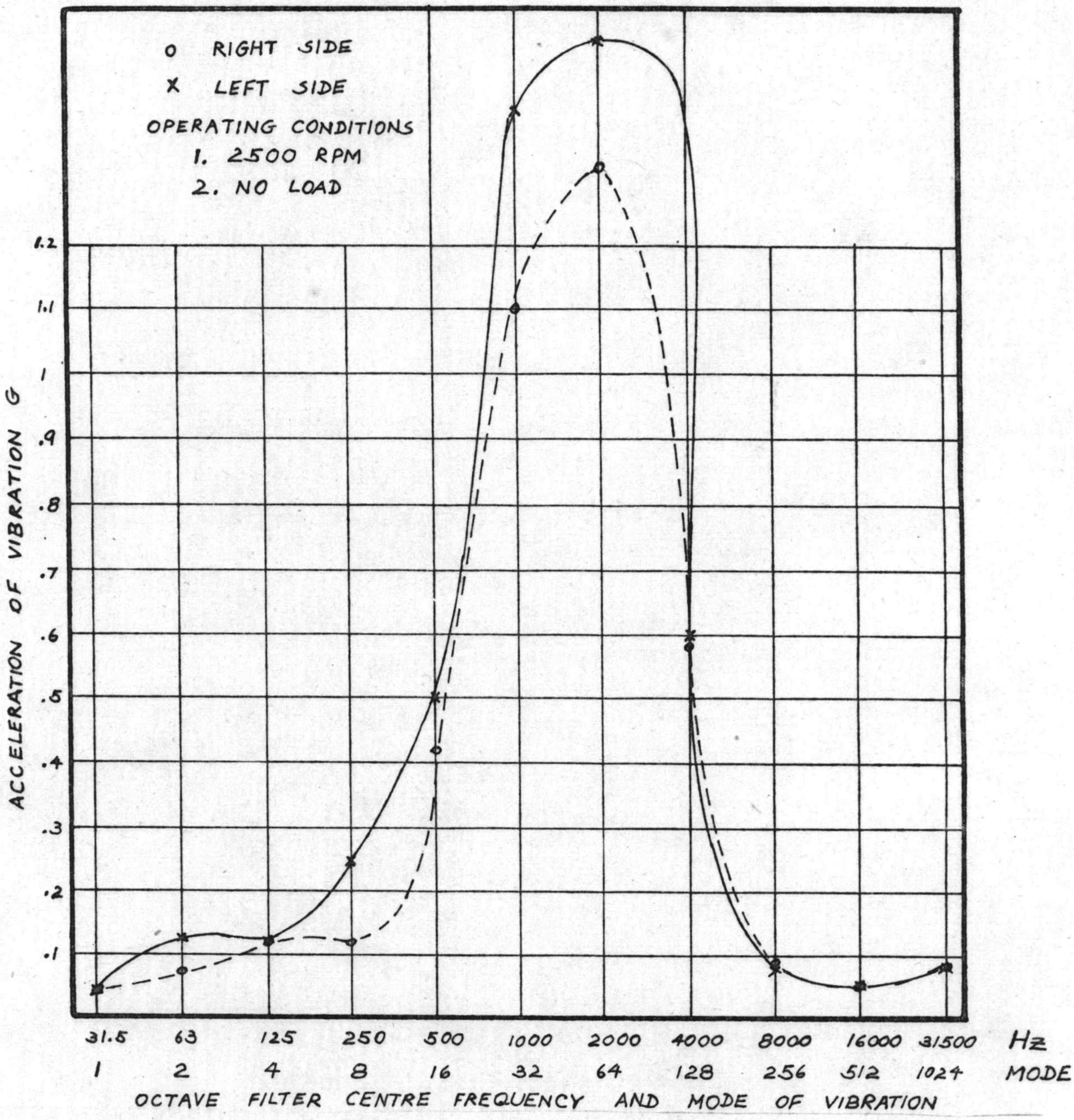

Fig.A-2 Acceleration of vibration plotted against mode of vibration at constant engine speed and no load

Experimental Calculation

Force produced by acceleration of vibration is

$$F = ma$$

where m = mass of engine

(a) For conventional engine

$$m \approx 130 \quad kg$$

$$F = 130 \times G \times 9.81 \quad kg\text{-}m/sec^2$$

$$= 1275.3\ G \quad kg\text{-}m/sec^2 \quad (RMS)$$

$$= 1803.27\ G \quad kg\text{-}m/sec^2 \quad (Peak) \quad (26)$$

where G = acceleration of vibration in unit of g

(b) For balanced engine

$$m = 156 \quad kg$$

$$F = 156 \times G \times 9.81 \quad kg\text{-}m/sec^2$$

$$= 1530.36\ G \quad kg\text{-}m/sec^2 \quad (RMS)$$

$$= 2163.92\ G \quad kg\text{-}m/sec^2 \quad (Peak) \quad (27)$$

For fourth mode vibromotive force, the calculations are similar by replacing A_2 with A_4 given in Table 2-1.

Results of secondary vibromotive forces are given in Table A-1 and Table A-2. These values are plotted in Fig. 4-17.

RPM	F Eq.25	G no load	F no load Eq.26	G full load	F full load Eq. 26
1000	237.64	.13	234.43	.36	649.18
1500	534.68	.32	577.05	.4	721.31
2000	950.54	.54	973.77	.55	991.8
2500	1485.23	.79	1424.58	.81	1460.68
3000	2138.72	1.17	2109.83	1.2	2163.93
3500	2911.04	1.6	2885.23	1.7	3065.56
4000	3802.17	1.9	3426.21	2.0	3606.54
4500	4812.13	2.42	4363.91	2.5	4508.18

Table A-1 Comparison Between Experiment and Theoretical Values of Secondary Vibromotive Force for Conventional Engine

RPM	F theory	G no load	F no load Eq.27	G full load	F full load Eq.27
1000	-	.13	281.31	.5	1081.96
1500	-	.115	248.85	.5	1081.96
2000	-	.078	168.79	.6	1298.35
2500	-	.05	108.20	.57	1233.43
3000	-	.18	389.51	.6	1298.35
3500	-	.3	649.18	.65	1406.55
4000	-	.4	865.57	.72	1558.02
4500	-	.5	1081.96	.75	1622.94
5000	-	.55	1190.16	.78	1687.86

Table A-2 Experimental Values of Secondary Vibromotive Force for Balanced Engine

VITA

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