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ON THE RELATION BETWEEN MAXIMUM PRESSURE AND SHOT—START PRESSURE

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Abstract

A simple linear relation between the maximum pressure and the shot-start pressure has been derived on the basis of a formula given in the Fiat Review of German Science (1939-45) and has been verified to be approximately true in the case of 3.7″ Howitzer and 5.5″ Gun, Mark III.

In the Fiat Review of German Science* (1939-46), an explicit expression for the maximum pressure in terms of the shot-start pressure is given, and when expressed in the notation of GM II, it can be written as

$$p_1 = \frac{FC}{A l \gamma M}\left(\frac{\gamma+1}{2\gamma}\right)^{\frac{\gamma+1}{\gamma-1}} + p_o\left(\frac{\gamma+1}{2\gamma}\right)^{\frac{2}{\gamma-1}} \qquad \ldots\ldots\ldots(1)$$

where p_o is the shot-start pressure.

The above formula has been derived on the assumption of a constant burning surface for the propellant, *i. e.* corresponding to $\theta=0$.

We see that the relation between the maximum pressure and shot-start pressure comes out to be linear, *i.e.*

$$p_1 = \frac{a}{M^2} + b\,p_o \qquad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where a_1 and b are constants.

In this paper, it has been verified that this linear relationship is approximately true, and that it is valid for values of θ other than zero also.

The maximum pressures for the various charges 1 to 5, corresponding to shot-start pressures of 0.5, 1.0 and 1.5 tsi in each case were calculated by G. M. II method for the 3.7″ Howitzer (charge A. N. .017, $\theta = 1$). The relationship between the maximum pressure and shot-start pressure comes out to be linear for each of the five charges (vide Table I and Fig. 1).

For charge 5, from the calculated values of p_1 for each p_o, a straight line was fitted by the method of least squares, for the equation (2). The values of the constants a_1 and b in equation (2) come out to be $a_1=23.1977$ and $b=0.841$. Hence the relation between p, and p, for the 3.7″ Howitzer is

$$p_1 = \frac{23.1977}{M^2} + 0{\cdot}841\,p_o \qquad \ldots\ldots\ldots\ldots\ldots(3)$$

With the help of this equation, the values of p_1 were calculated for various values of p_o for the other charges (1 to 4) using the appropriate value of M. The calculated values are given in Table 1. A comparison with the values calculated by GM II shows that the above linear relation may be approximately taken to be true, even

*Naturforschung und Medizin in Deutschland, 1939-1946 Band 7, Angewandte Mathematik, Teil V, p. 193.

for values of θ different from zero. *

It is easy to see that the equation (1) can also be put in the forms

$$p_1 = a_2 C^2 \omega_1^2 + b p_o \quad \ldots\ldots\ldots\ldots (4)$$

$$p_1 = a_3 F^2 + b p_o \quad \ldots\ldots\ldots\ldots (5)$$

and that the values of the constants a_2 and a_3 for 3.7″ Hows. are

$$a_2 = 0{\cdot}0366 \text{ and } a_3 = 2{\cdot}9528 \times 10^{-18}.$$

The values of the shot-start pressures, which give for various charges correct muzzle velocities, as given in range tables for a new gun, are as follows :

	M.V. f.s.	Shot start pressure tsi
Charge I	513	1.0
Charge II	578	1.0
Charge III	690	1.2
Charge IV	798	1.3
Charge V	962	1.5

Similar calculations were done for the 5.5″ gun Mark III for charges I to IV. The relation between p_1 and p_o is again seen to be linear (vide Fig. 2 and table II). Equation (2) cannot be applied to all the four charges since the web-sizes are not the same for all charges. But equation (2) was verified for charges III and IV for which the web sizes are the same, just as in the case of 3.7″ Hows. The values of a_1 and b were respectively,

$$a_1 = 76.806, \; b = 1.004$$

for charges III and IV of the 5.5″ gun Mark III.

TABLE I.

3·7″ How. A.N·017

	Shot-start pressure (tons per sq. in)	Maximum Pressure		M. V. f. s.
		by GM II tons per sq. in.	By formula (2) (tons per sq. in)	
Charge I				
3 oz. 13 dr.	0·5	1·68	1·362	469·7
	1·0	2·06	1·783	513·3
	1·5	2·48	2·203	545·8
Charge II				
4 oz. 10 dr.	0·5	2·12	1·807	546·4
	1·0	2·55	2·228	578·2
	1·5	2·96	2·648	599·0
Charge III				
6 oz. 2 dr.	0·5	3·26	2·867	667·0
	1·0	3·66	3·287	690·0
	1·5	4·03	3·708	720·0
Charge IV				
7 oz. 11 dr.	0·5	4·58	4·286	776·0
	1·0	5·06	4·706	795·0
	1·5	5·47	5·127	808·3
Charge V				
10 oz. 8 dr.	0·5	7·658	..	945·9
	1·0	8·098	..	954·4
	1·5	8·532	..	961·2

*It may be pointed out here that Mr. N. S. Venkatesan in his paper " A note on the Relation between Maximum Pressure and Shot Start pressure (Proc. Nat. Ins. Sci. of India, Vol. XVIII No. 4, 1952) has obtained a relation between p_1 and p_o for $\theta = 0$. According to his formula, even though the maximum pressure increases with shot-start pressure, the relation between the two cannot be expressed in a linear form.

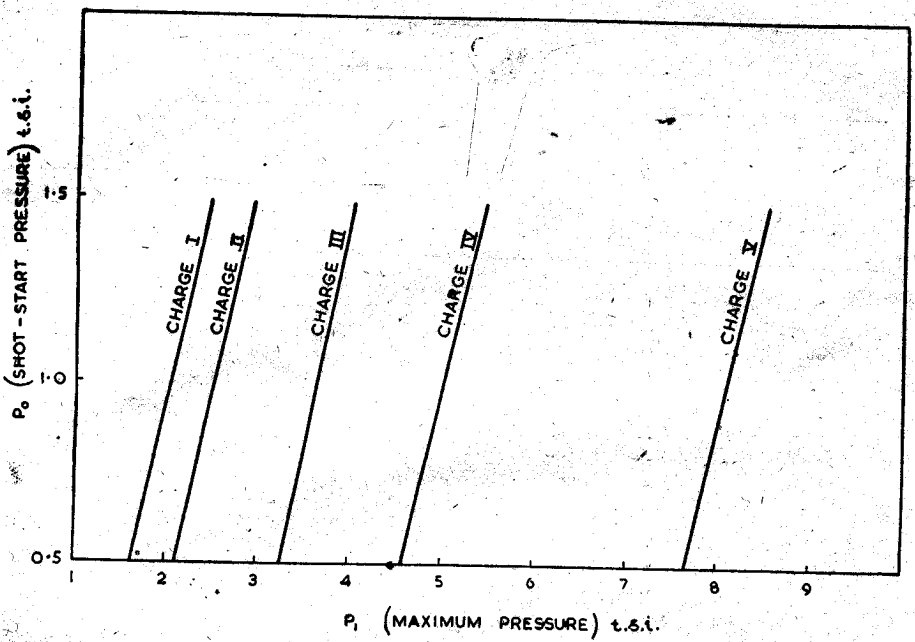

Fig. 1

Relation between Maximum Pressure and Shot-Start Pressure for 3.7" Howitzer.

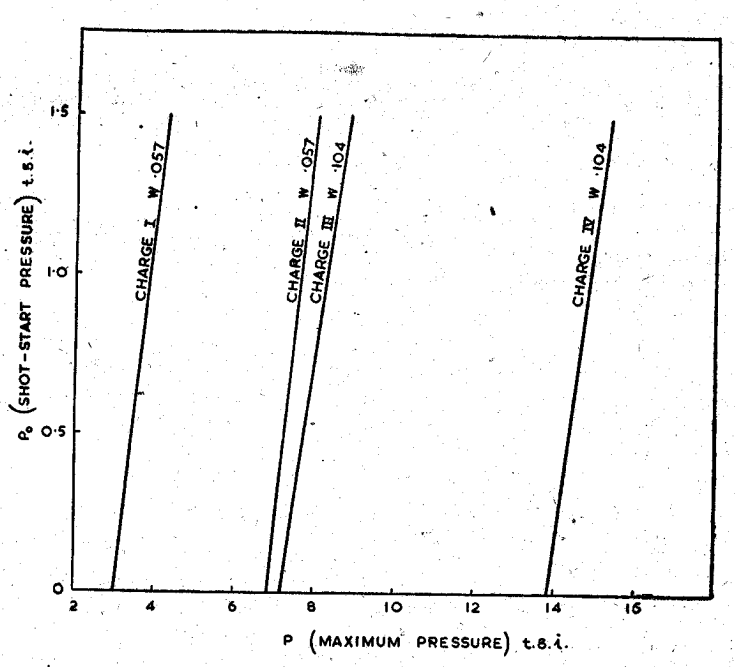

FIG. 2.

Relation between Maximum Pressure and Shot-Start Pressure for 5.5" Gun Mark III.

TABLE II.

5·5″ GUN MARK III

	Short Start pressure (tons per sq. in)	Maximum pressure	
		By GM II (tons per sq. in.)	By formula (2) (tons per sq. in.)
Charge I			
2 lb. 10 oz. 8 dr.	0	3·01	..
W. 057	0·5	3·49	..
	1·0	3·92	..
	1·5	4·31	..
Charge II			
4 lb. 4 oz. 0 dr.	0	6·87	..
W. ·057	0·5	7·28	..
	1·0	7·65	..
	1·5	8·07	..
Charge III			
6 lb. 10 oz. 8 dr.	0	7·19	7·267
W. ·104	0·5	7·76	7·769
	1·0	8·29	8·271
	1·5	8·86	8·773
Charge IV			
9 lb. 2 oz. 0 dr.	0	13·87	..
W. ·104	0·5	14·37	..
	1·0	14·88	..
	1·5	15·38	..