Price Complete, in Cardboard Box, 5s. net.

HORSE POWER COMPUTER

FOR

STEAM, GAS & OIL ENGINES

BY

HENRY A. GOLDING, A.M.I.M.E., A.M.I.A.E.

(Patented)

Explanatory Pamphlet accompanying this Instrument

LONDON

CHARLES GRIFFIN & COMPANY, LTD., EXETER STREET, STRAND

1908

HORSE POWER COMPUTER FOR STEAM ENGINES

Principle of the Instrument.—The computer is an ingenious form of mechanical calculator for solving the numerous problems connected with the power, size and speed of steam engines of all kinds. Its action is based upon the well-known principle of logarithmic calculation, the operations of multiplication and division being effected mechanically by the addition and subtraction of distances proportional to the logarithms of the quantities represented.

Description.—As will be seen from the illustration (p. 10), the computer consists of four concentric discs, A, B, C, and D, suitably provided with logarithmic scales to represent various quantities, such as boiler pressure, speed, size, and power. The lower disc, A, is provided with two scales, E and F, the former representing horse-power, and varying from 5 to 1000, and the latter (scale F) representing boiler pressure in lbs. per square inch absolute pressure, and extends from 10 lbs. to 400 lbs. These two scales E and F are in reality one continuous scale, the one being a continuation of the graduations of the other, the result being that the horse-power scale E is practically unlimited in extent, the lower portion of the boiler-pressure, scale F, being used for horse powers greater than 1000; and similarly the lower portion of the horse-power scale E can be utilised, if desired, for boiler pressures greater than 400 lbs. per square inch.

The second disc, B, mounted above A and rotating upon it, is furnished with two scales, G and H, the outer scale G representing the number of expansions employed from 1 to 40, and the inner scale H being graduated for various values of "diagram factor" from 0·5 to 1·0. The graduations of the scale G are proportional to the co-efficient of isothermal expansion, $\frac{1+\log_\epsilon r}{r}$, where r represents the ratio or number of expansions employed. For multi-cylinder engines, the number of expansions taken is from the point of cut-off in the high-pressure cylinder down to the end of the stroke in the low-pressure or final cylinder. Similarly the value of "diagram factor" H, used for multi-cylinder engines, will be the combined diagram factors of all the cylinders composing the engine; or the ratio of the total mean effective pressures in all the cylinders referred to the low-pressure cylinder, to the theoretical mean effective pressure obtained by expanding steam hyperbolically from the boiler pressure r times.

The next disc, C, also contains two scales, J and K, the former scale. J, on the outer edge representing the stroke of the engine varying from 6 inches to 10 feet, and the inner scale K representing the speed of the engine in revolutions per minute from 20 to 600. The scale K is continued to form an extension scale K_1, representing the ratio of cylinder areas, the use of which will be explained later.

The upper disc, D, is also provided with two scales, L and M, the former representing diameters of cylinders (for multicylinder engines, the diameter of the low-pressure cylinder) varying from 6 inches to 120 inches, and the extension carrying the scale M to read off scale E representing various mechanical efficiencies from 0·5 to 1·0, being provided with an indicator N at unit efficiency termed "I.H.P. indicator."

Application to Gas and Oil Engines.—For gas and oil engines working on the Otto cycle of operations with one power stroke for every two revolutions of the engine, the two scales G and H on disc B are not required. When the mean effective pressure is known, set the index 1 on the expansions scale G to the given mean effective pressure on scale F, and set the stroke of the engine on scale J to the index 1 on the diagram factor scale H, then set the number of explosions per minute (or one-half the number of revolutions per minute when working at full load) on scale K to the diameter of the cylinder on scale L, when the I.H.P. will be given on scale E opposite the index 0·5 on the mechanical efficiency scale M.

Application to Single-acting Steam Engines.—When using the computer for single-acting engines giving one power stroke for each revolution of the crank, read the I.H.P. on scale E off the index 0·5 on the mechanical efficiency scale M.

Application to Steam Engine Problems.—The uses to which the computer can be put in solving the various problems in steam engine design connected with the horse power, size, speed, and pressure, are very numerous, but the following are a few of the more important ones, a consideration of which will indicate generally the scope of the instrument.

Example I.—To find the I.H.P. of any engine, given the sizes of the engine, speed, and pressure. Set the number of expansions on scale G to the boiler pressure on scale F. Read the theoretical mean effective pressure on scale F opposite 1 on scale G, and subtract a suitable back pressure (say 3 lbs. for condensing engines, and 16 lbs. for non-condensing engines) by rotating disc B anti-clockwise. Set the given stroke on scale J to a suitable value of diagram factor on scale H; set the diameter of the cylinder (or L.P. cylinder as the case may be) on scale L to the given speed in revolutions per minute on scale K, and the indicator N will point to the I.H.P. on scale E.

Example II.—To find the B.H.P. of any engine, given sizes, speed and pressure. Set the various discs as explained in I., and opposite the mechanical efficiency on scale M read the B.H.P. on scale E.

Example III.—To find the theoretical m.e.p. for a given boiler pressure and number of expansions. If the boiler pressure be given in lbs. per square inch gauge pressure, add 15 lbs. to allow for the pressure of the atmosphere, and subtract a suitable amount for loss of pressure between boiler and engine (say 5 or 10 lbs.). The result will be the steam pressure at the engine in lbs. per square inch absolute pressure. Set the given number of expansions on scale G to this pressure on scale F, and opposite 1 on scale G read off the theoretical m.e.p. on scale F.

Example IV.—To find the actual mean effective pressure for a given value of diagram factor. Set the expansions on scale G to the steam pressure on scale F as explained in III., then subtract a suitable back pressure (either 3 or 16 lbs.), set 1 on stroke scale J to the given diagram factor on scale H, bring 1 on diagram factor scale H to 1 on stroke scale J, and opposite 1 on scale G read actual m.e.p. on scale F.

Example V.—To find the boiler pressure required for a given power, size of engine and speed. Reverse the operations described in I., starting with the given I.H.P., when 1 on scale G will point to the theoretical m.e.p. required on scale F, or the given number of expansions on scale G will point to the required steam pressure on scale F. As this is absolute pressure, subtract 15 lbs., and add a suitable amount for loss of pressure between boiler and engine.

Example VI.—Given power, pressure, and size of engine, to find speed required. Set expansions on G to boiler pressure on F, subtract back pressure, set stroke of engine on J to diagram factor on H, set indicator N to given I.H.P. on scale E, or the mechanical efficiency on scale M to the given B.H.P. on scale E, and opposite the diameter of (L.P.) cylinder on scale L read the required speed in revolutions per minute on scale K.

EXAMPLE VII.—Given power, diameter, speed and pressure, to find stroke required. Set expansions on G to boiler pressure on F, subtract back pressure, set indicator N to I.H.P. on E, or mechanical efficiency M to B.H.P. on E, set revolutions per minute on J to diameter of (L.P.) cylinder on L, and opposite the given diagram factor on H read off the required stroke on scale J.

EXAMPLE VIII.—Given power, pressure, stroke and speed, to find diameter of L.P. cylinder required. Set expansions on G to boiler pressure on F, subtract back pressure, set stroke on J to diagram factor on H, set indicator N to I.H.P. on E, or mechanical efficiency M to B.H.P. on E, and opposite the known revolutions on scale K read the required diameter of L.P. cylinder required on scale L. To find the sizes of the other cylinders, set 100 on scale K against diameter of L.P. cylinder on scale L, and opposite the ratio $\left(\frac{\text{L.P.}}{\text{H.P.}}\right) \times 100$ on scale K, read the diameter of the high pressure cylinder on scale L. Or, opposite the ratio of $\left(\frac{\text{L.P.}}{\text{I.P.}}\right) \times 100$ on scale K, read the diameter of the intermediate pressure cylinder on scale L.

EXAMPLE IX.—To find the size of two L.P. cylinders each of the same size. Proceed as in VIII. and find the size of the equivalent single L.P. cylinder. Then set 100 on scale K to this diameter, and opposite 200 on K read diameter of each of the two L.P. cylinders on L. The readings on the instrument do not take into account the area of the piston rod, as these are practically negligible, only affecting the result by 1 or $1\frac{1}{2}$ per cent. If necessary, it could be allowed for by making the cylinder slightly larger than the size indicated on the rule, say the next even figure in diameter.

Quite a large number of minor calculations can be effected by the aid of this computer, in addition to those just mentioned, such as to find the size of steam pipe to bear a given ratio to the size of cylinder; or to find the mechanical efficiency, given I.H.P. and B.H.P.; or to find the piston speed, given stroke and revolutions; or to find the number of expansions for a given m.e.p. and boiler pressure; but sufficient has been said to show the general scope of the operations performed by the aid of the instrument. Engine designers will find this instrument of the greatest possible assistance to them in so adjusting what may be termed the movable or variable quantities to suit given conditions, such as where power and pressure only are known, the various speeds at which different sizes of engines must run to develop the required power can be seen at a glance, and that size of engine chosen which will conform most economically to the given conditions. Another great advantage possessed by this instrument over the ordinary slide rule is that different quantities consisting of the same significant figures are found in different places on the power computer, whereas on the ordinary slide rule the index points to the same place on the rule for such widely differing results as 1·7, 17, 170, and 1700. With this form of power computer these four results are found in four distinct and separate places; in other words, the computer solves the difficulty of knowing where to put the decimal point, which is one of the most common objections to the use of the slide rule raised by practical men.

For the guidance of the operator in determining the values of the best ratio of expansion for different boiler pressures, and the approximate values of diagram factors obtained with typical engines, we give below two tables of approximate values which represent the means of average working results obtained in actual practice. The actual value taken will vary somewhat according to the conditions of working and with different makes of engines, so that the following may only be taken as a guide in the absence of more exact figures obtained under the actual conditions of working for the particular type of engine in question.

TABLE OF THE MOST ECONOMICAL NUMBER OF EXPANSIONS.

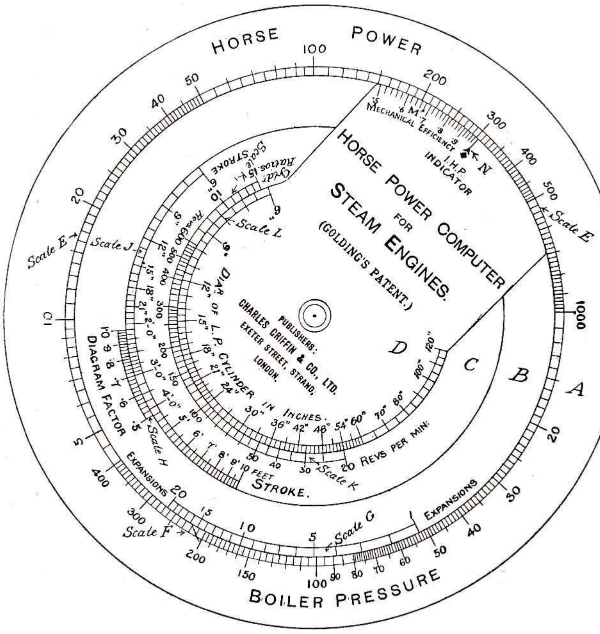
Type of Engine.		Boiler Pressure, in lbs. per sq. in. Gauge Pressure.								
		60	80	100	120	140	160	180	200	250
Non-Condensing	Single Cylinder	2·5	3	3·5	...	...	...	...	...	...
	Compound	3·5	4	4·5	5	...	...	...	...	...
	Triple Expansion	...	...	...	8	9	10	...	...	...
Condensing	Single Cylinder	3·5	4·5	5·5	...	...	...	...	...	...
	Compound	...	6	7	8	9	10	...	...	...
	Triple Expansion	...	...	...	10	11	12	13	14	16

TABLE OF APPROXIMATE DIAGRAM FACTORS FOR TYPICAL ENGINES.

			Jacketed.	Non Jacketed.
Single Cylinder Engines		Non-condensing	0·83	0·78
		Condensing	0·8	0·75
Compound Engines	Slide Valves	Non-condensing	0·73	0·7
		Condensing	0·7	0·68
	Drop or Corliss Valves	Non-condensing	0·78	0·75
		Condensing	0·75	0·72
Triple Expansion, Condensing		From	0·62	
		To	0·72	
		Mean	0·67	
Quadruple Expansion, Condensing		From	0·58	
		To	0·65	
		Mean	0·62	

Typical Exercises on the Use of the Instrument.

EXAMPLE I.—To find the diameter of cylinder required for a small single-cylinder steam engine to develop 40 B.H.P. non-condensing, with steam at 60 lbs. pressure, cutting off at $\frac{1}{2}$ stroke, with speed (say) 120 revolutions, and stroke 18 inches. Set 2 expansions on scale G to 60 lbs. pressure on scale F, read theoretical m.e.p. (50·7) lbs. on F. Substract 16 lbs. by setting 1 on G to 34·7 on F, set 18-inch stroke on J to 0·78 on H, set 0·9 mechanical efficiency on M to 40 on E, and read diameter of cylinder ($13\frac{7}{8}$ inches) on scale L, opposite 120 on K.



Example II.—To find the I.H.P. of a compound engine, L.P. cylinder 24-inch diameter, stroke 3 feet, revolutions 100, boiler-pressure 160 lbs., expansions 10. See illustration on this page. Set 10 on scale G to 160 on scale F.

Read m.e.p. on F, opposite 1 on G. Subtract a suitable back pressure, set 3-feet stroke on J to 0·7 on H, set 24 inches on L to 100 on K, and read I.H.P. (304) off N on scale E.

Example III.—To find the B.H.P. of above engine, with a mechanical efficiency of 0·88. Read B.H.P. direct on scale E, opposite 0·88 on scale M (267).

Example IV.—To find diameter of high-pressure cylinder of above engine, given ratio of cylinder areas = 2·75. Set 24 inches on L to 100 on K, and read diameter of high-pressure cylinder ($14\frac{1}{2}$ inches) on L, opposite 275 on K (see illustration, p. 10).

Example V.—To find the diameters of cylinders for a compound engine to develop 200 B.H.P., with 160 boiler-pressure and a piston speed of 400 feet per minute. Set 10 on G to 160 on F, read m.e.p. (53 lbs.) on F, opposite 1 on G, subtract 3 lbs. for back preseure, set 6-inch stroke on J to 0·7 diagram factor on H, set 0·88 mechanical efficiency on M to 200 on E, and read diameter of low-pressure cylinder ($26\frac{1}{8}$ inches) on scale L opposite 400 feet per minute (piston speed) on scale K. To find revolutions, rotate disc C and set stroke (say 2 feet) to diagram factor 0·7 on H, and opposite L = $26\frac{1}{8}$ inches read speed = 100 revolutions per minute. To find size of high-pressure cylinder, set 100 on K to $26\frac{1}{8}$ inches on L, and read diameter of H.P. cylinder on L, opposite ratio $\left(\frac{\text{L.P.}}{\text{H.P.}}\right) \times 100$ on scale K. Say $\left(\frac{\text{L.P.}}{\text{H.P.}}\right) = 3$, then H.P. cylinder = $15\frac{1}{8}$ inches diameter found on L, opposite 300 on scale K.

Example VI.—To find the diameters of cylinders required for a triple expansion engine to develop 800 B.H.P., say 4 feet stroke at 70 revolutions, with 200 lbs. boiler pressure. Set 14 on G to 200 on F and read m.e.p.

(52 lbs.) off F opposite 1 on G. Subtract 3 lbs., and set 4 feet on J to 0·67 on H, set 0·85 (assumed mechanical efficiency) on M to 800 on E, and opposite 70 on K read diameter of L.P. cylinder ($46\frac{1}{2}$ inches) on L. Let ratio $\frac{\text{L.P.}}{\text{H.P.}} = 8$, and ratio $\frac{\text{L.P.}}{\text{I.P.}} = 3$, set 100 on K to $46\frac{1}{2}$ inches on L, and read sizes of high-pressure ($16\frac{1}{2}$ inches) and intermediate (27-inch) cylinders off L opposite 800 and 300 on K respectively.

Example VII.—To find the stroke of a high-speed compound, single-acting engine, with 30-inch low-pressure cylinder, to give 200 I.H.P. at 300 revolutions per minute, with 120 lbs. boiler pressure, working condensing. Set 8 on scale G to 120 on scale F, read m.e.p. (46 lbs.) off F opposite 1 on G, subtract 3 lbs., set 0·5 on scale M to 200 on scale E, and 300 on K to 30 inches on L, and read stroke (12 inches) off J opposite 0·72 on H.

Example VIII.—To find the I.H.P. of a gas engine, cylinder 10-inch diameter, stroke 16 inches, explosions per minute = 100, assumed mean effective pressure = 80 lbs. Set 1 on G to 80 on F, set 16 inches on J to 1·0 on H, set 10 inches on L to 100 on K, and read I.H.P. (25·5) on E opposite 0·5 on M.

Example IX.—To find the B.H.P. of a petrol motor, with 6 cylinders, each 6-inch diameter, stroke 6 inches, revolutions per minute = 1000, assumed mean effective pressure = 66 lbs. Set 1 on G to 66 on F, set 6 inches on J to 1·0 on H, set 6 inches on L to 500 (*explosions*) on K, and read I.H.P. per cylinder (14·1) off E opposite 0·5 on M. Total I.H.P. = $14·1 \times 6 = 84·6$.

Example X.—To find the diameter of steam pipe required for a 60-inch cylinder, if the velocity of the steam be 15 times the mean velocity of the piston. Set 60 inches on L to 100 on K, and opposite 15 on K_1 read diameter of pipe required ($15\frac{1}{2}$ inches).