Reg Thomas
book 2

BEACON
MEMO BOOK
12¾ x 8 in. Ref. 12B2
OPENS FLAT

1st Prototype Engine Cam Lifts 2-11-62

Exhaust

Degrees	Thous	Degrees	Thous
95° A.T.D.C.	0	260°	314.5
100°	1-5	270°	310-8
110°	12	280°	301.2
120°	26-6	290°	286
130°	49	300°	269
140°	74	310°	248
150°	105	320°	224-4
160°	137.3	330°	198-5
170°	170	340°	166
180°	201-6	350°	137.4
190°	232	360°	106.7
200°	257	10°	78.5
210°	277	20°	53
220°	249.2 294.2	30°	34
230°	306	40°	19
240°	313	50°	8
250°	314-6	60°	2.2
		68°	Closed.

Inlet

Degrees	Thous	Degrees	Thous	Degrees	Thous
315° A.T.D.C.	0	60°	214.7	170°	182-8
320°	1.2	70°	232.7	180°	151
330°	7.9	80°	243.8	190°	121.5
340°	19	90°	252.5	200°	91.5
350°	36	100°	257.8	210°	64
360°	56	110°	262.5	220°	41.5
10°	81	120°	265.3	230°	25-5
20°	109.5	130°	262-5	240°	12
30°	141.1	140°	251.7	250°	3.1

Valve Springs 30/11/62

As 42692 but 9½ swg (·136" dia wire)

= 39 lbs @	1 5/16"	47-51	
58½ @	1 1/8"	77-81	Standard
82 @	1"	102-106	
93 @	15/16"	115/120	

10 swg (·128" dia wire)

= 31 lbs @ 1 5/16
47 lbs @ 1 1/8
65 lbs @ 1
74 lbs @ 15/16

Primary ~~Chains~~ Chain Tensioner

Spring Blade 36/- per 100 = 4·32d — Tools £25
Moulding of Rubber 8d each — " £56
Total 12·32d each — Tools £81

Plastic Moulded Type (Thermoplast)
£2-1-8d per 100 = 5d each — Tools £130

INDUSTRIAL AIR COMPRESSORS by F.G. WHITE 36/-
G.T. FOULIS & Co Ltd, 1-5 PORTPOOL LANE, LONDON E.C.1
First published 1967

Atmospheric Pressure 14·7 pounds per square inch at sea level.
equivalent to a barometric reading of 29·92 inches of mercury.

1 Kilogramme per square centimetre = 14·22 pounds per square inch

14·7 pounds per square inch = 1·033 metric units.

'ata' denotes 'atmospheres absolute'

'atu' or ato denotes pressure above that of atmosphere.

A cubic foot of air at 14·7 lbs/$\square''$ and at a temperature of 60°F weighs ·076 pounds

Thus:- one pound of air occupies a space of 13·06 cubic feet.

PV = Constant (Boyle's law)

Thus:- Pressure is inversely proportional to Volume
Volume " " " Pressure

$\frac{PV}{T}$ = Constant (Charle's Law)

Thus:- when Pressure is constant, Volume is proportional to temperature.
" Volume " ", Pressure " " " "

Pressure and temperature are expressed in <u>absolute</u> values.

Isothermal compression - compression at constant temperature

Adiabatic " - compression without heat extraction

(Isentropic–reversible adiabatic) (i.e. temperature rises)

Absolute pressure = gauge pressure + 14·7 pounds per square inch.

The expression for adiabatic temperature ratio is:

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^m \ldots \text{ hence } T_2 - T_1 = T_1\left(\frac{P_2}{P_1}\right)^m - T_1$$

where T_1 is the absolute temperature at inlet
P_1 is the absolute pressure at inlet
P_2 is the absolute pressure at outlet
m is a constant, 0·286 for air

Absolute temperature = Degrees C plus 273
Degrees F plus 460

STATE EQUATION $p_1 V_1 = m R T_1$ (m = mass, R = characteristic gas constant)

VOLUMETRIC EFFICIENCY = $\frac{\text{Vol of free Air taken in per cycle}}{\text{Swept Vol.}}$

$$\eta v = 1 - C\left(r_p^{\frac{1}{n}} - 1\right)$$

(r_p = pressure ratio i.e $\frac{P_3}{P_1}$ & C = Clearance Vol. as fraction of stroke)

P_1 = LBS/SQ FT

WORK DONE PER MINUTE

$$\frac{n}{n-1} p_1 V_1 \left\{ \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1 \right\} \text{ -------- ① ft lbf}$$

HORSEPOWER = $\frac{\text{WORK DONE PER MINUTE}}{\text{33 000 × MECHANICAL EFFICIENCY}}$

ISOTHERMAL WORK DONE PER MINUTE

$$p_1 V_1 \log_e \frac{P_2}{P_1} \text{ -------- ② ft lbf}$$

ISOTHERMAL EFFICIENCY = $\frac{②}{①} \times 100$ %

At constant temperature $P_1 V_1 = P_2 V_2$

With all heat retained $\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^n$

adiabatic

$$\boxed{\begin{array}{l} \frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} \\ \hline \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} \end{array}}$$

n = the ratio of specific heats of air or gas being compressed (1.406 for air)

The expression n is often used for the mean compression index

The ratio of specific heats often appears in the compound form $\frac{n-1}{n}$

and frequently given a symbol viz. $m = \frac{n-1}{n}$, also $\frac{1}{m} = \frac{n}{n-1}$

Adiabatic

The mean effective pressure over the whole stroke is given as

$$\frac{n}{n-1} \times P_1 \times \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \text{ (p.s.i.)}$$

Theoretical power = $\frac{\text{mep} \times \text{cfm}}{33,000}$ (pressures in lbs/□ foot)

Isothermal

$$\text{mep (isothermal)} = P_1 . \log_e \frac{P_2}{P_1} \text{ (p.s.i.)}$$

($\log_e$ is the hyperbolic log = 2.3 times the common log)

Theoretical h.p. = $P_1 \log_e \frac{P_2}{P_1} \times \frac{144}{33,000}$ per cubic foot/min

$$= \frac{\text{mep (pounds per sq. foot)}}{33000}$$

R = Gas constant = 53.3 ft lbs per lb, for air.

$PV = RT$

VALVE CALCULATIONS

~~Pis~~ $$\text{GAP AREA}^{(\text{SQ. INS})} = \frac{\text{PISTON AREA (SQ. IN)} \times \text{PISTON VELOCITY (FT/SEC)}}{\text{REQD. VALVE VELOCITY (FT/SEC)}}$$

Reasonable Oil Consumption

(100 cu ft / 100 lbs / 100 hrs / Pint

Enthalpy is energy possessed by the mass.
H is total enthalpy   h is unit enthalpy

A LITTLE LIGHT RELIEF

A two-lobe Wankel compressor is being developed

REDUCED COST resulting from the adoption of a two-lobe rotor is the key to the new Wankel compressor being developed by Borsig GmbH in West Berlin. This Wankel could displace reciprocating compressors in many applications but especially where weight and noise are problems.

An electrically driven Wankel unit complete with ancillaries weighs 65 kg compared with 120 kg for an equivalent reciprocating unit, and is much smaller. This compressor has a capacity of 0·6 m^3/min (21 ft^3/min) and a continuous rating of 690 kN/m^2 (100 lbf/in^2). It is expected to go into production within two or three months—at no cost penalty compared with the reciprocating unit.

Borsig's involvement in this development goes back to 1959 when it became co-holder with Wankel GmbH of the Wankel compressor rights. At that time the Wankel was seen as a challenger to the typical industrial compressor in the 35-150 kW input power range, and so would have extended the range of Borsig products.

The company had been established in 1837 and for about 100 years concentrated on the manufacture of big steam engines and then turbines. During the last war the company started to make exhaust turbochargers for big diesels and also produced large numbers of machine guns. Then, Borsig was the largest it has ever been with 17 000 employees. Some of the plant was destroyed at the end of the war.

In the 1950s the product range was gradually extended with the emphasis on large steam generators, equipment for chemical plant, and a number of special purpose compressors and turbines.

Complex and costly. Borsig started on the Wankel compressor project so early the first design had a stationary three-lobe piston with a rotating trochoidal housing. There was a further stationary housing and so the compressor was inevitably complex and costly.

Borsig developed the project through and by 1968 had the compressor ready for production. In the meantime the screw compressor had been developed and its performance/cost balance soon put the Wankel in the shade. Borsig—a member of Gruppe Deutsche Babcock—quietly dropped the Wankel and from then on it became a word with expensive connotations in the company.

It was decided to look afresh at Wankels in 1971. Gerhard Schindelhauer, head of design and production for series compressors, took control of the project on which there are now six people working.

This time the emphasis was on finding a sector of the market where the inherent advantages of the Wankel were most worthwhile. It soon became clear that this was where reciprocating compressors tend to hold sway—small units which are often portable.

Schindelhauer puts the range at 0·1-2·5 m^3/min (3·5-70 ft^3/min) with a continuous output at 690 kN/m^2 and an intermittent maximum rating of about 940 kN/m^2 (145 lbf/in^2). For higher outputs Schindelhauer says the screw compressor is cheaper to produce.

The adoption of a two-lobe rotor is the vital feature of the Borsig compressor. Schindelhauer lists these main advantages:

☐ It has the minimum clearance volume of the Wankels at 1·7% in theory and 5% on the Borsig units;

☐ The swept volume: housing diameter ratio is greatest;

☐ Only one valve is needed instead of two;

☐ Machining involves the use of relatively simple equipment.

In this design the transfer ratio—the diameter of the phasing gears on the housing to that in the rotor—is 1:2 and the housing bore is virtually circular over two thirds of its length. The bore is almost heart-shaped with the curve first going outside the true circular form and then dipping inside the true circular form towards the apex.

This shape is dictated by the rotor radius: eccentricity ratio, and Borsig adopted the smallest ratio that maintained a concave shape throughout the bore. This configuration gives a simple overall shape—the curve diverges only 3 mm from a true circle—with a small leaning angle for the apex seal, while the clearance volume is small.

The rotor has two lobes whose fac can be machined as arcs—70 m radius on the portable unit—and it tates at half the speed of the eccent shaft. Schindelhauer puts the optim trochoid diameter: chamber width ratio as 2-3:1 but considers 4:1 acceptable. Varying the width is one way of making a range of similar compressors with different outputs.

Ingenious features. Borsig's first Wankel project has been developed under contract to a Continental company that makes equipment for the constructio industry, and is a portable electricall driven unit. The compressor is moun directly on the shaft of a 4 kW electri motor so that one of the compresso bearings supports one end of the mo —eliminating the need for one bearin Another ingenious feature is that th

All the basic elements of the Wankel are simple