TESTS OF A KNOX TWO-CYLINDER AUTOMOBILE

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THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN MECHANICAL ENGINEERING

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

FRANK WOODBURY CUTLER and EUGENE CROUSE KENYON

ENTITLED TESTS OF A KNOX TWO-CYLINDER AUTOMOBILE

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

L. P. Breckenridge.

HEAD OF DEPARTMENT OF Mechanical Engineering

I N D E X .

TEST OF A KNOX AUTOMOBILE.

PRELIMINARY REMARKS.

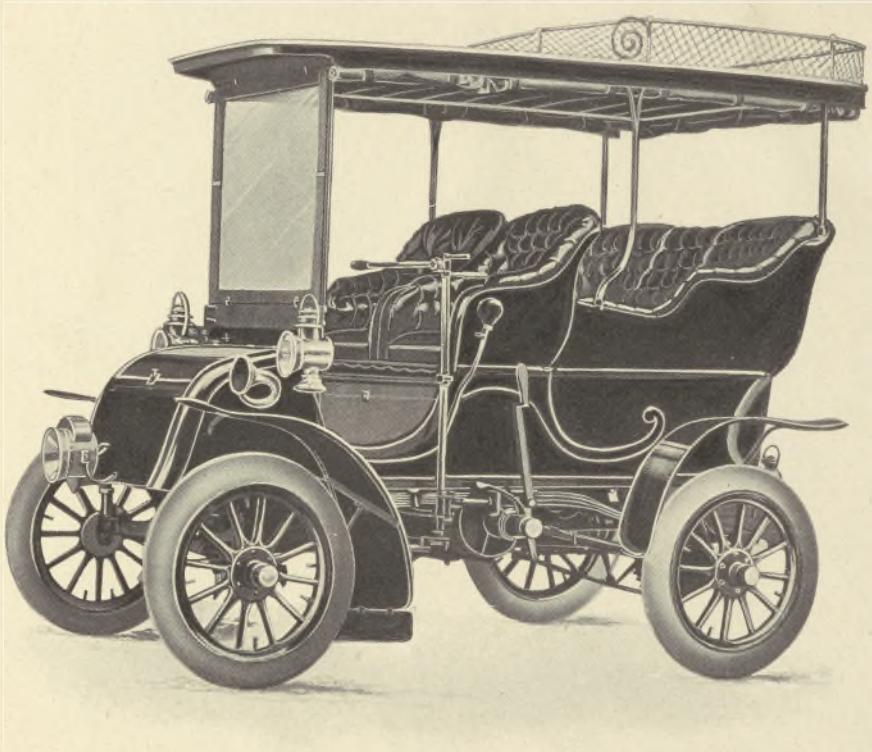
During the fall of 1904, "Automobile Testing" was chosen by the undersigned as the subject for their thesis work for the Degree of Bachelor of Science in Mechanical Engineering in the University of Illinois. After some correspondence with the Knox Automobile Co. of Springfield, Mass., the Knox Co. kindly put their 1904 model, two cylinder, air cooled car, No. 1432, at the disposal of the University for testing purposes. These tests were not taken to obtain data for comparison with records of other machines, but had for their purpose the obtaining of an accurate knowledge of the adjustments of the various parts of the Knox engine itself, to give best results.

Owing to delay in preparing a suitable place for such a series of tests as we proposed making, actual work on the machine was not commenced until near March 1, 1905. The machine was first placed in good condition. The spiral gears were replaced, new make and break points, spark plugs and batteries were put in, and each cylinder was tapped for 1/2" indicator connections. The whole machine was carefully cleaned and inspected.

DESCRIPTION OF CAR.

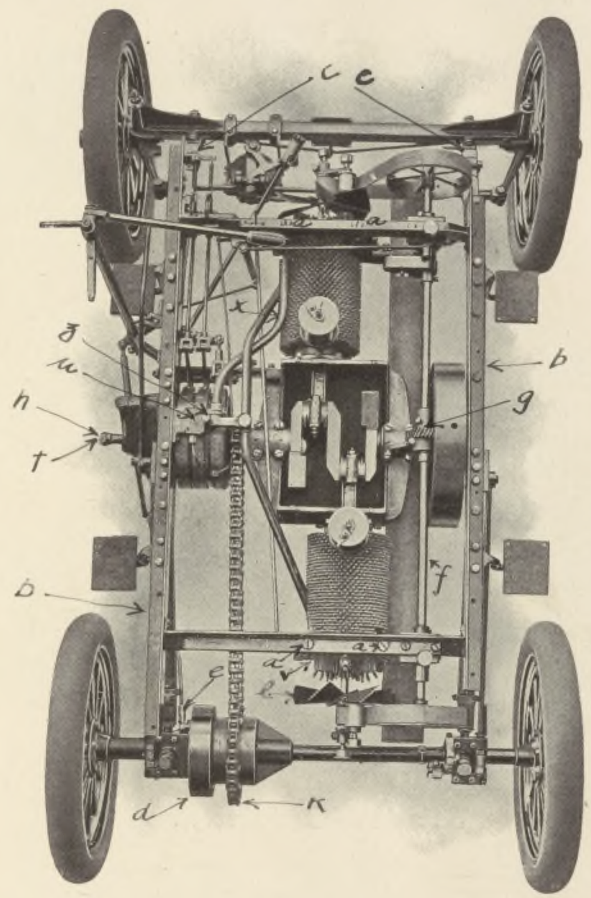
(Plate I shows the car complete.)

The Knox engine has two horizontal opposed cylinders (see Fig. 1, pp. 5). Theyare of the medium speed, four cycle type, with 5" bore and 7" stroke, placed close up under the body and hung from the frame by means of the four bolts (a). The frame (b) is made of angle steel reinforced at the corners and is bolted to heavy side springs (c) with swivel ends, which insures a very easy riding car and reduces the shocks to which the motor is subjected. (d) is bevel gear differential on the rear axle which carries a double acting emergency brake (e) and the rear sprocket wheel. (f) is a 1" secondary shaft driven by spiral gears (g) from main engine shaft (h), ratio 2 to 1. This secondary shaft operates the exhaust valves by means of cams and also operates the make and break device explained below. The transmission (i) is of the planetary type giving two speeds forward and one reverse. The high speed is a direct chain drive from sprocket (j) to sprocket (k). Fig. 2, pp. 6 shows one of the air cooled cylinders which is studded with 1/4" soft iron radiating pins, 3" in length, and are threaded their entire length in order to give large radiating surface. A draft of air is forced through these pins by means of the fans (l) driven by belt from the secondary shaft. The ignition system is shown in Fig. 3, pp. 9 . (a) is a cam on the secondary shaft which has two grooves diametrically opposite each other. (b) is a flat spring under tension so as to cause nipple (t) to drop into these grooves as the cam revolves, thus bringing the two platinum points at (e) in quick contact and separating them again once for each revolution of the engine shaft. (H) is a simple coil with two circuits, called the primary and secondary. The primary or low voltage circuit,cfgenm,has four dry cells (K) in series and the operator's plug on the dash board serves as a switch. The secondary or high voltage circuit connects the remaining two binding posts of the coil (S and S') in series with the two spark plugs (P and P'). The two wires of these spark plugs are separated exactly 1/16", one wire being insulated from the machine by means of porcelain and the other in direct connection with the machine. As cam (a) revolves the current in the primary circuit is made and broken quickly as each groove passes the nipple (T). When the circuit in the primary is broken, a current of high voltage is induced in the secondary circuit causing a hot spark to jump across the separated wires of each spark plug. Ignition will take place only in that cylinder in which compression has just occured. The cylinders and wrist pins are oiled from an oil resevoir (s), Fig. 1 pp. 5 by a small plunger pump operated by a ratchet mechanism on the secondary shaft. The oil enters the cylinders at the points (r). The main shaft bearings and crank pin boxes are lubricated by means of hard grease forced in from grease cups (t) through the center of the engine shaft. The atomizer is of the float feed type and keeps the gasoline at a constant level in the small reservoir (u). The suction of the pistons through the automatic inlet valves (v) draws warm air through tube (x) and draws a spray of gasoline from a small nozzle leading from the atomizer. The flow of gas-



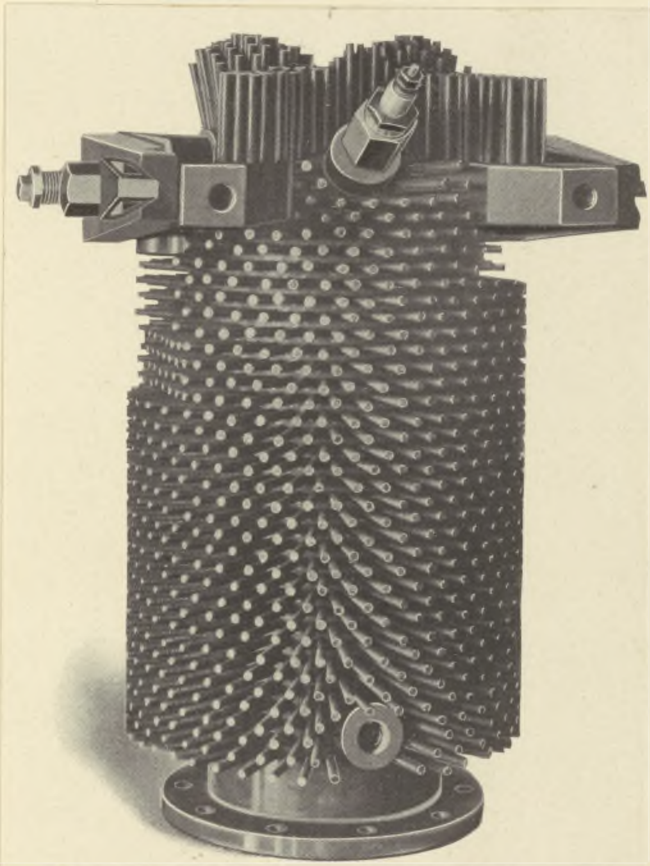
Knox "Tudor" Touring Car
Two Cylinder

PLATE I.



Chassis, Knox Two-Cylinder Cars

FIGURE I.



Knox Cylinder, showing the heat radiating corrugated pins on exterior.

FIGURE 2.

oline through this nozzle is regulated by the small screw (z). Both inlet and exhaust valves are of the conical seat type, the inlet valves being automatic. Proper tension to hold the inlet valves on their seats is obtained by a light coil spring.

DESCRIPTION OF APPARATUS.

In order that all parts of the machine might be rendered easily accessible, the machine was mounted on a platform 20 feet long by 8 feet wide by 2- 1/2 feet high, having a three foot o- pening, the length of the machine. The top and side views of this platform are shown in Fig. 4 following.

Plate II is a photograph of the machine and apparatus as they stood ready for a test, showing indicators and indicator re- ducing mechanism and Prony Brake especially well. The tires were removed from the front wheels which were then firmly blocked in order to hold the machine in place. Over each corner of the machine was hooked a 1/2" rod in which was a turnbuckle. These rods were bolted to the platform below and the turnbuckles tight- ened, bringing compression upon the springs of the machine, thus preventing all vibration.

The power was absorbed by a Prony brake which was keyed to an inch and one quarter shaft two feet long; this shaft was in turn connected at one end to the main engine shaft by means of a steel collar, the other end supported by a bearing, which was bolted firmly to the floor, thus doing away with much vibration.

The manner of support and connection are shown in Fig. 5 . The brake was designed especially so as to easily take care of any horse power which the machine would develop, the bearing surface being 20" in diameter, and 4" wide.

Fig. 6 shows the brake as it worked. Water was carried to the inside flange of the brake through pipe (c). Pipe (d) carried away the hot water, so that the water was kept continuously changing throughout the test, thus insuring a cool brake. A piece of fat bacon placed at (e) insured even lubrication. The pressure on the brake of the blocks (b,b) was varied by means of the hand wheels (a,a). The pressure on the end of the brake arm (c) measured by a platform scale, correctly calibrated and very sensitive, was transmitted through the knife edge (d). The brake arm was 30-7/8 inches in length; it was found that a longer arm was not sensitive enough.

The total number of revolutions of the main shaft of the engine was recorded by means of an automatic stroke counter run from the secondary shaft of the machine by spur gears whose ratio was 2 to 1. Since the ratio of revolutions of the secondary shaft to that of the main shaft was 1 to 2, one count of the recorder was equal to four revolutions of the main shaft.

The engine received its gasoline supply as is shown in Fig. 7 . The carburetor mechanism was connected by means of rubber tubing to a 3/8" pipe (d,d) which led to a 2" pipe (e). An upright glass tube connected to the 2" pipe by a gauge cock showed the height of the gasoline in (e). Even with the top of (e) was placed a pair of express scales, which weighed to fractions of an

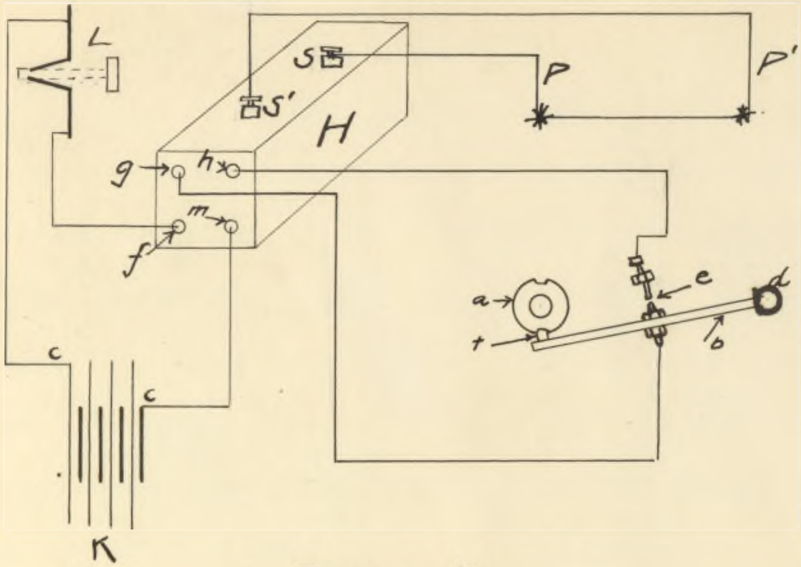


FIGURE 3

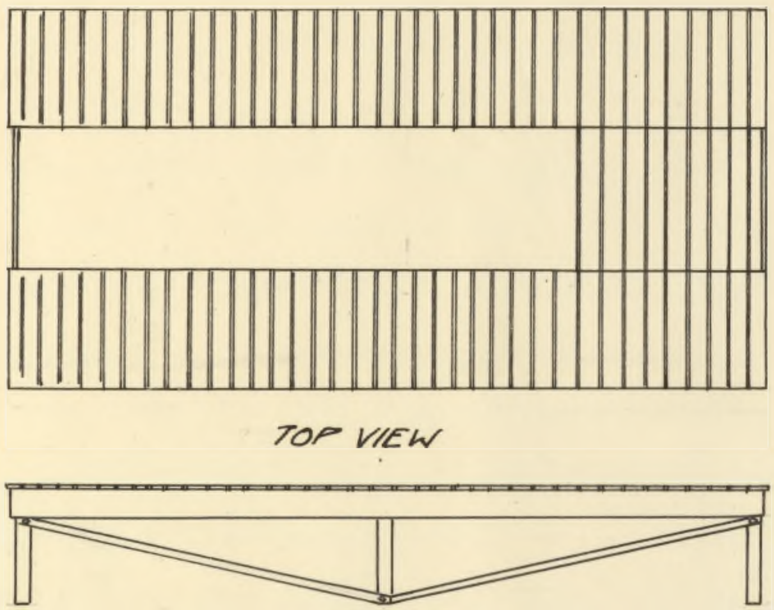


FIGURE 4.

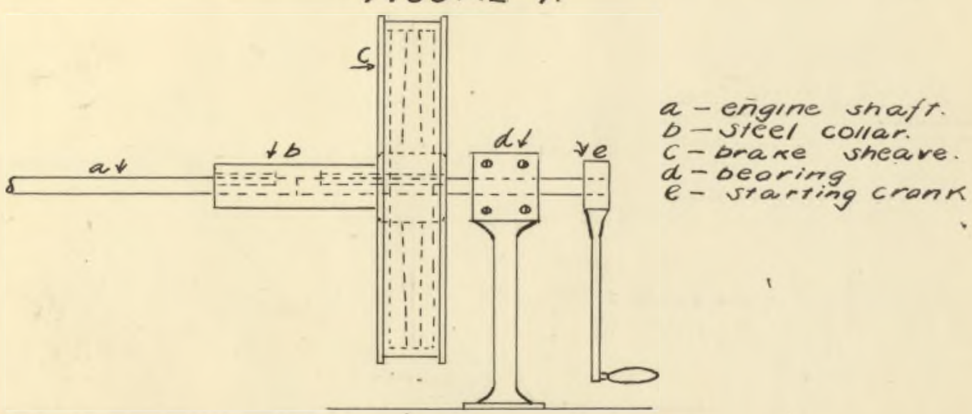


FIGURE 5.

ounce. On these scales was placed the gasoline can which had a faucet (g) through which the gasoline was run into (e). At the beginning of a test the exact height of gasoline was marked by placing a thread around the glass tube at that height and the weight of the can and gasoline was recorded. At the end of the test the gasoline was brought back to this height and the weight of both again taken. The difference was the amount of gasoline used. Tests where gasoline consumption was taken were at least of thirty minute duration.

The temperature of the muffler gases was taken by means of a thermometer placed at the end of the muffler directly in the path of the escaping gases.

A radiating pin was removed from each cylinder, just over the clearance space. Just after the engine was stopped in each test, a thermometer was inserted in these holes and the temperature of the cylinder walls noted.

It was found that the engine under full load running at slow speed would notcool properly while standing still, since the conditions for cooling while standing still in a hot room are far from being those while the machine is moving outside. Compressed air was piped to the machine and into a 3/8" pipe which was bent around each cylinder just over the clearance space. These pipes were perforated, on the sides next the cylinder and away from the fans, with small holes, through which the air rushed onto the cylinders keeping them well cooled.

The frame was loosened from the cylinders and lifted clear. The cylinders were then blocked up on a drill press and just over

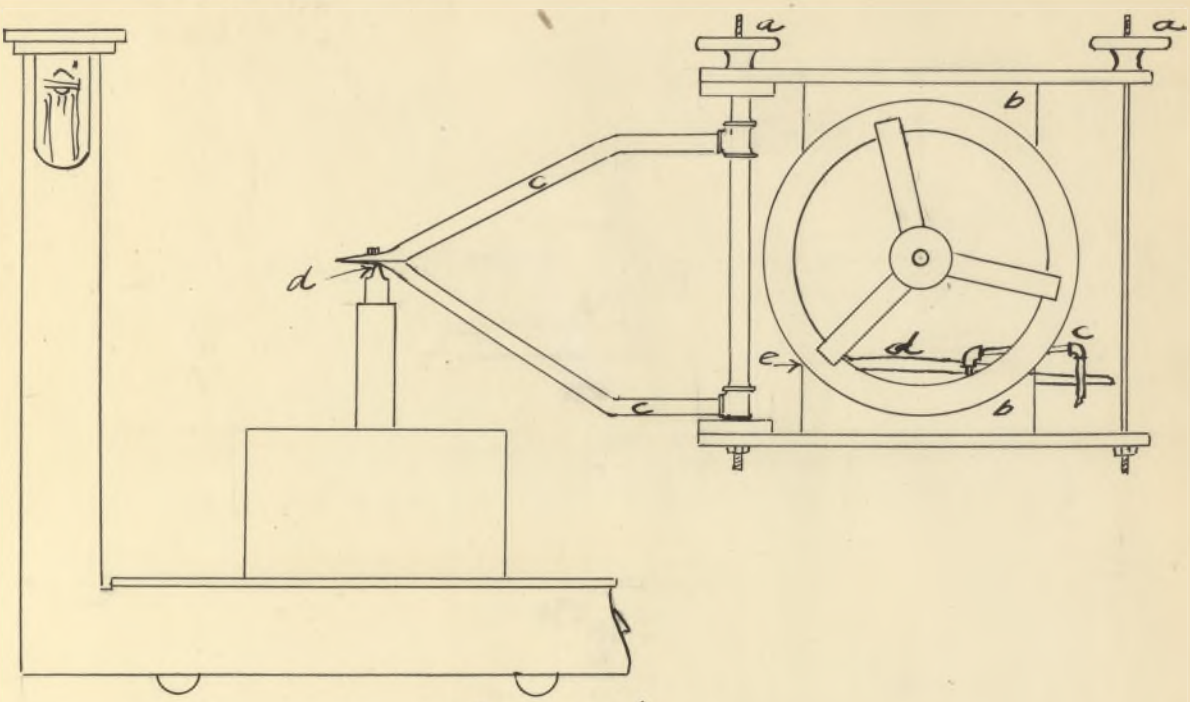


FIGURE 6

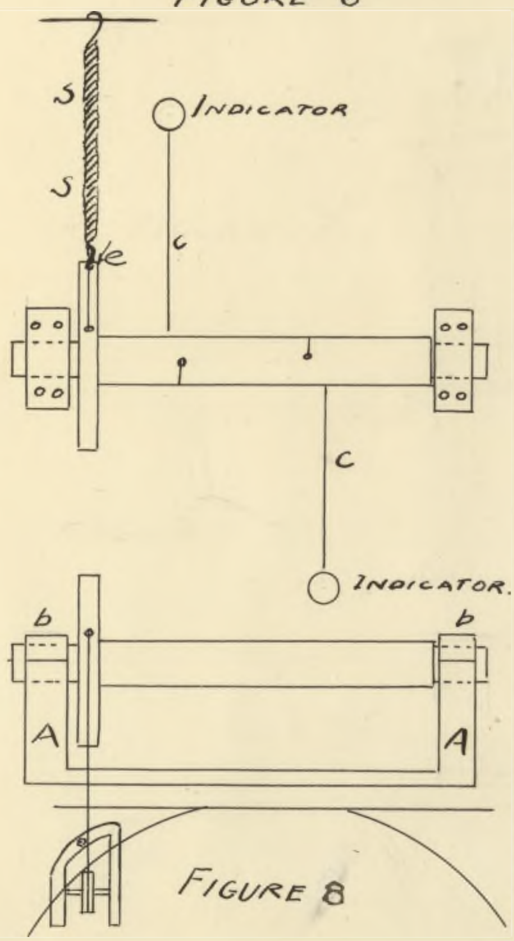


FIGURE 8

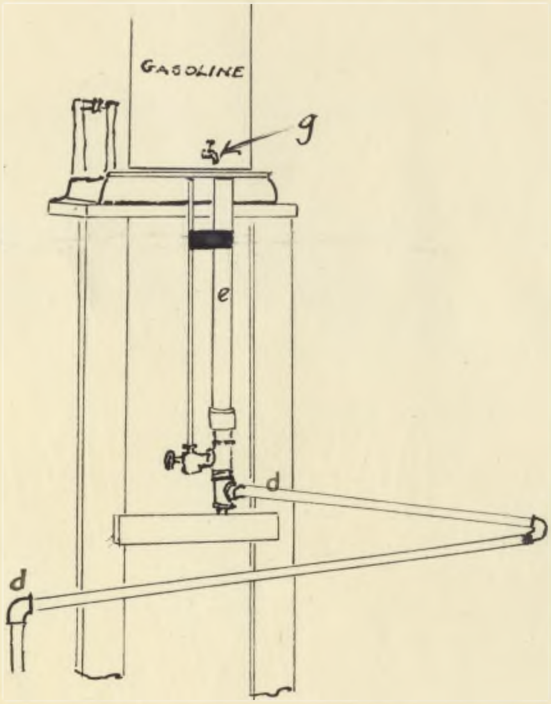


FIGURE 7.

the clearance space of each, holes were drilled and tapped for 1/2" pipe. The frame was then fastened on, pipes inserted in the holes and indicators attached to the pipes. Cards were taken by means of the reducing mechanism shown in Fig. 8 .

This mechanism consisted of a wooden frame work (A) upon the bearings (b,b) of which revolved a wooden cylinder 2-1/2" in diameter. This cylinder transmitted the reduced motion of the piston to the indicator through the cords (c,c). Fastened to this cylinder and rotating with it was a wooden wheel, 7" in diameter, to which was fastened a cord. This cord passed over the wheel and over another pulley, which was on line with the center of the cylinder and fastened to the wrist pin. As the piston moved back and forth the wooden wheel and cylinder revolved, first in one direction and then in the other, a heavy spring (s,s) fastened at e taking up the slack in the cord. Cards were taken only on tests averaging 500 R.P.M. or below.

Great care had to be taken with the cord to insure its not breaking. A braided cord of three strands of the best indicator cord was used from the piston to the wheel and all other cord used was carefully stretched. This rig was objectionable on account of the cord stretching and breaking, but since it was impossible to get another motion in the space provided the mechanism had to be used.

Pointers were attached to the throttle and spark advance which swept over scales, graduated in degrees , as the position of the throttle or spark advance was changed. This gave a means of knowing the opening of the throttle and the time of ignition during any test.

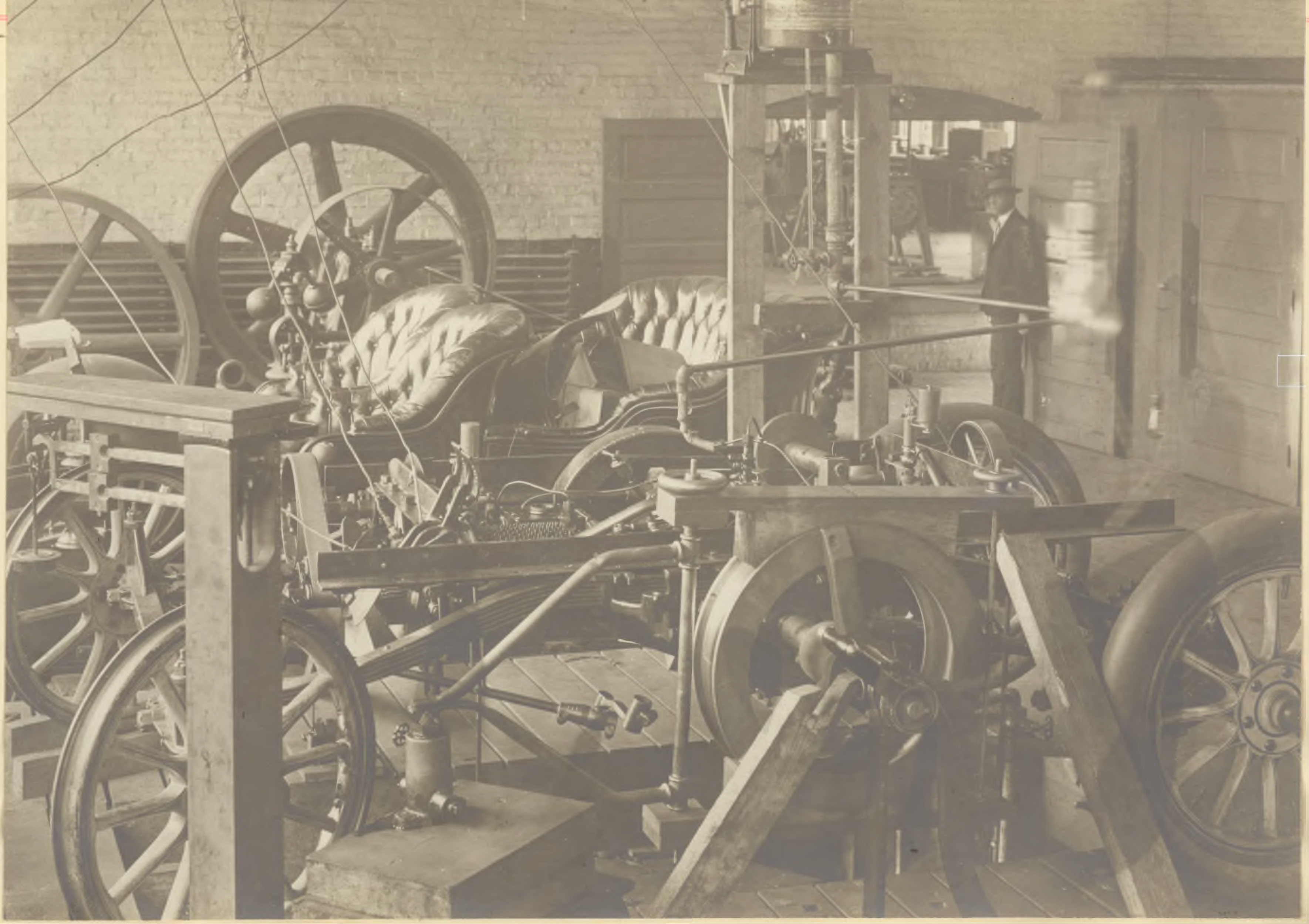


PLATE II.

ITEMS USED IN CALCULATIONS.

Following are the items shown on the sample data sheets and items used in calculating results.

1, The number of the test.

2. Time of starting and stopping test and time of each reading.

3. Reading of platform scales (pounds net pressure).

4. Gasoline consumption in pounds and ounces.

5. Temperature of gases from muffler.

6. Temperature of cylinder walls after stopping engine. This temperature was always taken at a point just in front of the spark plugs.

7. Settings of throttle and spark advance.

8. Brake Horse Power = $\frac{2\pi PlN}{33000}$, where P = net pressure on platform scales (item 3); l = length of brake arm in feet, = 2.573; N = average revolutions per minute of engine shaft.

9. Mean Effective Pressure. Computed from indicator cards (see sample pp. 20); equals net area of card, measured by planimeter, divided by the length of card.

10. Indicated Horse Power = $\frac{PlaN}{33000}$, where P = M.E.P. (item 9) l = length of stroke in feet, = .5833; a = area of piston in square inches, = 19.62; N = average revolutions per minute of engine shaft.

11. Mechanical Efficiency = $\frac{B.H.P.}{I.H.P.}$

12. Miles per hour which the machine would travel computed from R.P.M. of engine shaft, = $\frac{60\ N\ a\ \pi\ d}{b \times 12 \times 5280}$

where a = number of teeth in front sprocket, = 10; b = number of teeth in rear sprocket, = 31; d = diameter of driving wheel, = 31.5 inches (tire flattened 1/4"); N = R.P.M. of engine shaft.

13. When the engine is on dead center a notch on rim of fly wheel is directly opposite the upper surface of flange on side of crank case. A series of notches, one inch apart are filed on the rim of the fly wheel and numbered 0, 1, 2, etc. so that as the engine is turned backward from its dead center position, each notch in succession comes opposite the flange. In the following pages when it is said that any event takes place at a certain notch, it means that this notch is opposite the crank case flange when this event takes place.

LIST OF TESTS

made on Knox Car No. 1432.

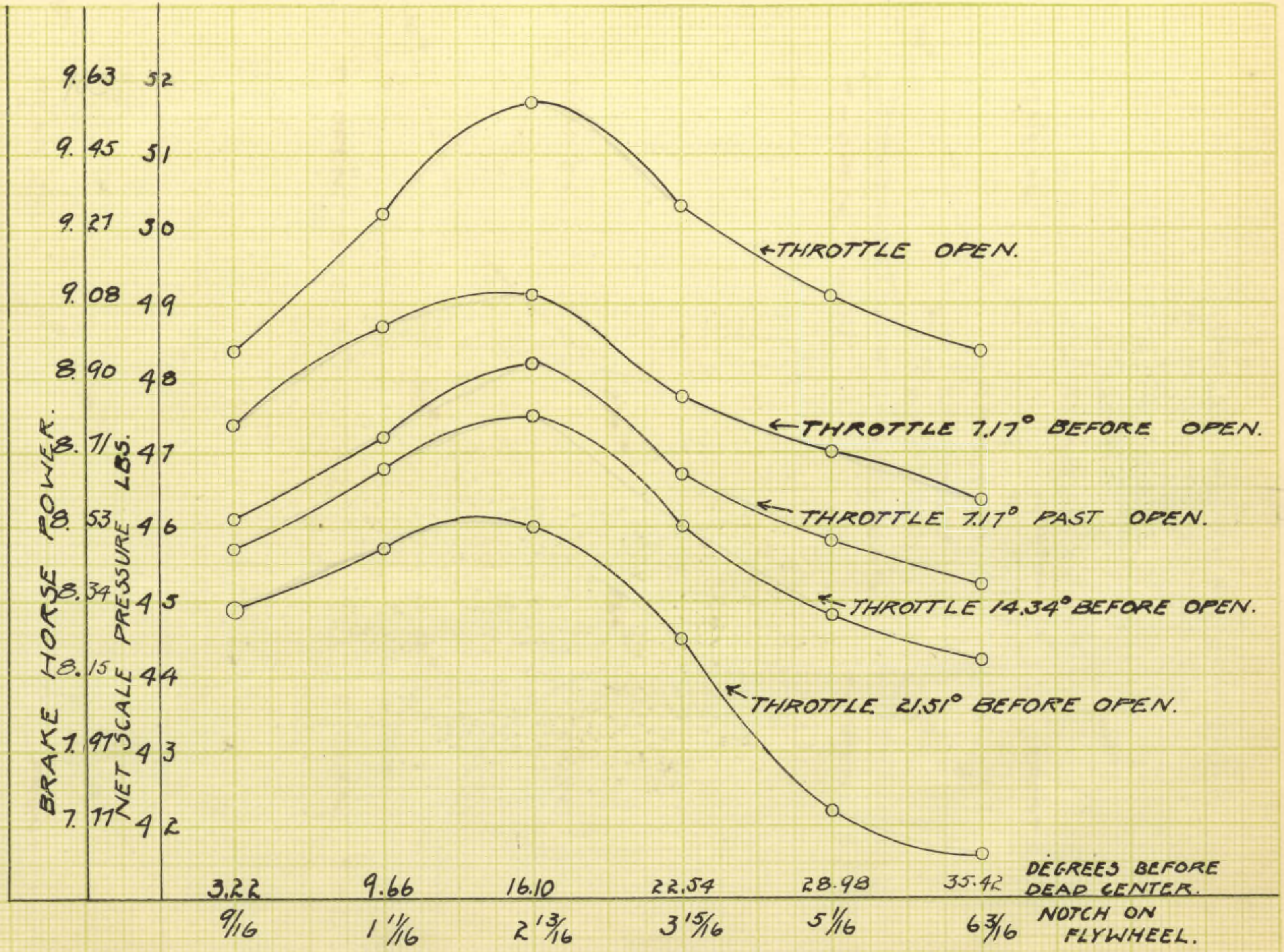
TEST NO. I.

(a) A series of 36 tests each of 10 minutes duration was taken to determine the relative position of the throttle and spark advance which would give the maximum tractive effort that the engine could exert. 366 R.P.M. of the engine shaft, which would give the car a speed of 10.9 miles per hour, was assumed to be about the speed under which the maximum tractive effort would be required, assuming that the car was being driven on direct drive up grade or over heavy roads where tractive effort and and not speed would be the condition required. The tractive effort exerted by the machine would be proportional to the pressure on the platform scales, hence these pressures may be taken as a measure of the tractive effort which the machine would actually exert on the road.

The R.P.M. of the engine shaft during these tests was kept as near constant as possible and the pressure on the scales calculated, which would give the same horse power at 336 R.P.M. which was chosen as a good average.

The following curves show the results of this test. It is seen that the time of ignition to give best results, is at 16.10° before dead center, i.e., when the crank pin is 16.10° before the end of the stroke. The throttle wide open gives the most power, 7.17° less than open and 7.17° past open giving considerably less power.

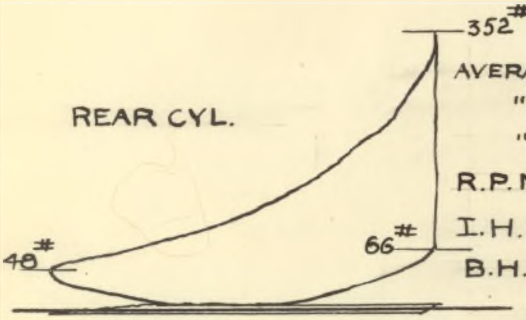
(b) The relative positions of throttle and spark advance to give maximum power having now been found, a series of tests with throttle and spark advance set at these points with six different settings of the atomizer adjustment screw (see pp. 7) and the point where maximum power was developed was recorded. (See (c), Test No. II.)



CURVES SHOWING RELATION BETWEEN THROTTLE AND SPARK ADVANCE AT 366 R.P.M.

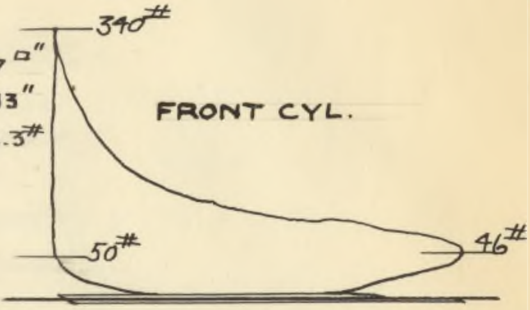
TEST NO. 1.

SAMPLES OF INDICATOR CARDS TAKEN DURING TEST NO. I (a)

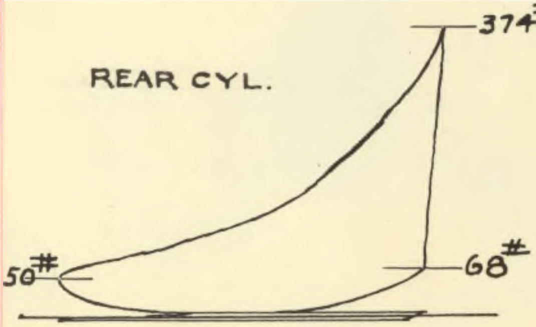


T-OPEN. S-16.10°

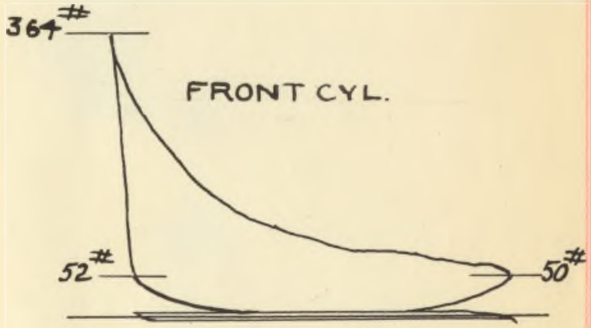
AVERAGE AREA = .87 □"
" LENGTH = 2.13"
" M.E.P. = 92.3#
R.P.M. = 398
I.H.P. = 11.95
B.H.P. = 9.60
EFF. = 80.5 %



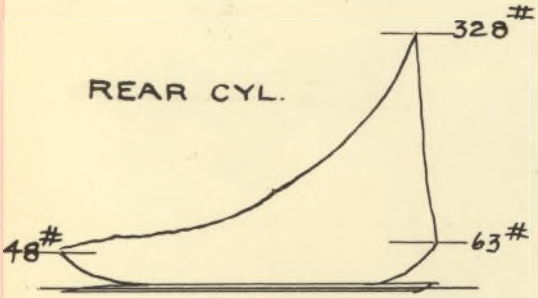
T-OPEN. S-16.10°



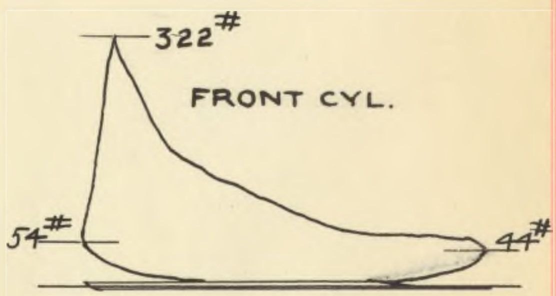
T-OPEN. S-22.54°



T-OPEN. S-22.54°



T-OPEN. S-9.66°

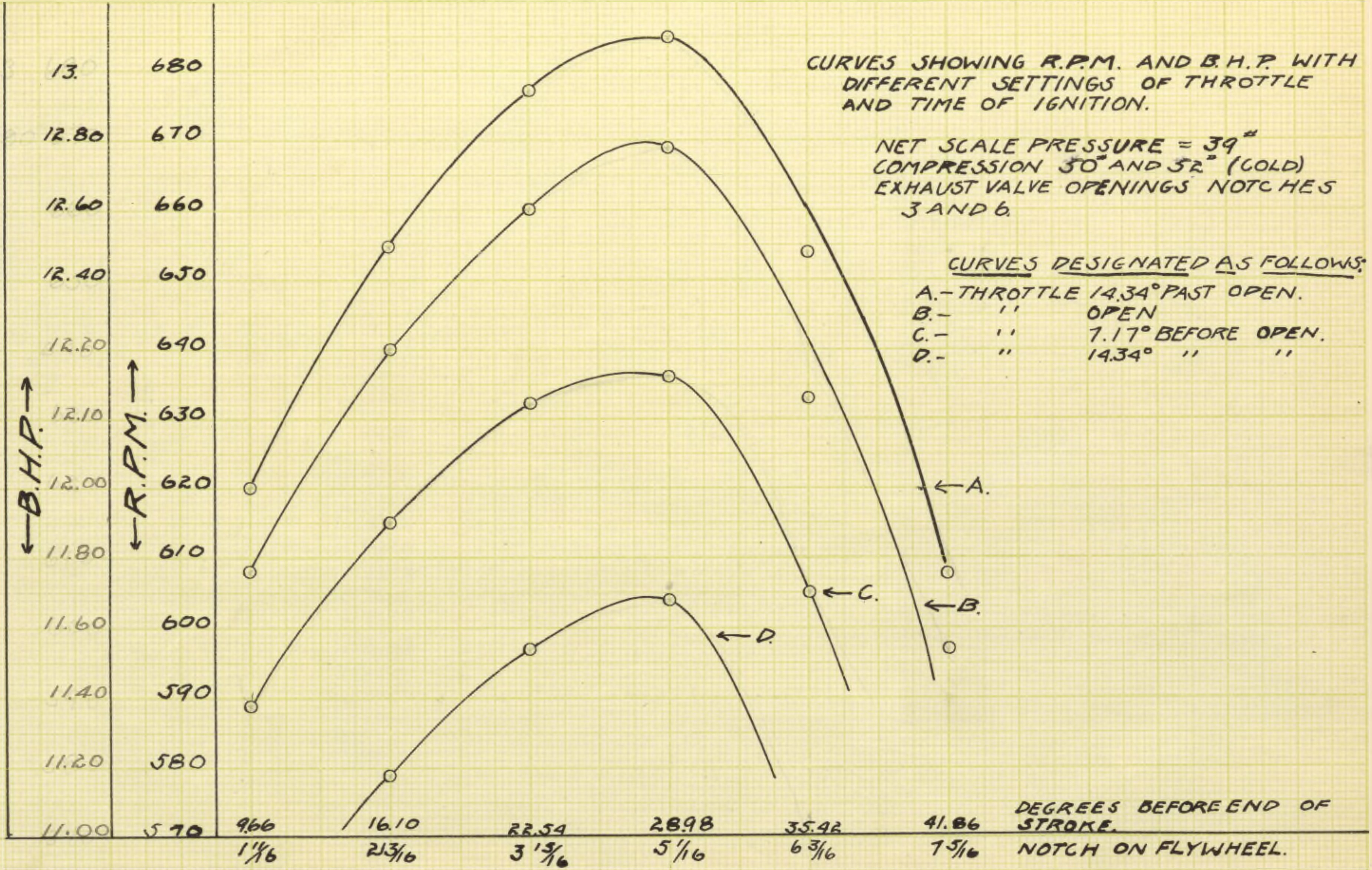


T-OPEN. S-9.66°.

TEST NO. II.

(a) A series of 36 tests each of 10 minutes duration was taken to determine the relative position of throttle and spark advance to give maximum speed. A pressure of 39 pounds of the scales kept constant at all combinations of throttle and spark advance, and the speed allowed to vary. On pp.23 is shown a sample of the data taken during these tests. No indicator cards could be taken at these high speeds which were satisfactory, hence the mechanical efficiency of the engine at high speeds could not be ascertained.

The curves on pp.22 show the results of these tests. The maximum speed was obtained with the throttle 14.34° past its open position and ignition taking place at 28.98° of crank pin travel before dead center which corresponds to notch 5-1/16 on rim of fly wheel. If ignition were made at an earlier point than the above, the speed decreased rapidly as may be seen from the curves,and pounding and overheating took place.


CURVES SHOWING R.P.M. AND B.H.P. WITH DIFFERENT SETTINGS OF THROTTLE AND TIME OF IGNITION.
NET SCALE PRESSURE = 39#
COMPRESSION 50" AND 52" (COLD)
EXHAUST VALVE OPENINGS NOTCHES 3 AND 6.
CURVES DESIGNATED AS FOLLOWS:
A.– THROTTLE 14.34° PAST OPEN.
B.– " OPEN
C.– " 7.17° BEFORE OPEN.
D.– " 14.34° " "
←B.H.P.→
13.
12.80
12.60
12.40
12.20
12.10
12.00
11.80
11.60
11.40
11.20
11.00
←R.P.M.→
680
670
660
650
640
630
620
610
600
590
580
570
9.66
16.10
22.54
28.98
35.42
41.86
DEGREES BEFORE END OF STROKE.
1 1/16
2 13/16
3 15/16
5 1/16
6 3/16
7 5/16
NOTCH ON FLYWHEEL.
←A.
←B.
←C.
←D.

TEST NO. 2.

TEST OF KNOX AUTOMOBILE #1432.

MECH ENG DEPT.
UNIVERSITY OF ILLINOIS.

THESIS OF CUTLER AND KENYON 1903

TEST #2.

No.	Time	Throttle and Spark	R.P.M.	Net Pressure on Scales Lbs.	B.H.P.	Gasoline Consumption	Temp. of Muffler Gases °F	Temp of Cyl. Walls after stop °F	Remarks.
1.	9^{30}	SET WITH T OPEN S 16.10° OF CRANK PIN TRAVEL BEFORE END OF STROKE	642				311		EXHAUST VALVE FRONT CYLINDER CLOSED DEAD CENTER. BEGAN OPENING 5 NOTCHES = 28.70° BEFORE END OF STROKE. " " REAR " " 2 NOTCHES = 11 48° BEFORE DEAD CENTER. BEGAN OPENING 3 NOTCHES = 17.22° BEFORE END OF STROKE.
	9^{31}		639						
	9^{32}		638						
	9^{33}		640						
	9^{34}		639	39		38.6			
	9^{35}		637				310		
	9^{36}		639						
	9^{37}		639						
	9^{38}		637						
	9^{39}		638				314	310°F	
AVER			638.9		12.22				
2.	9^{50}	T OPEN S 22.54° BEFORE DEAD CENTER	662				312		
	9^{51}		663						
	9^{52}		660						
	9^{53}		659						
	9^{54}		659	39		39.8	314		
	9^{55}		658						
	9^{56}		659						
	9^{57}		660						
	9^{58}		659						
	9^{59}		660				313	312°F	
AVER			659.9		12.59				
3.	10^{15}	T OPEN S 28.98° BEFORE DEAD CENTER	672				315		
	10^{16}		670						
	10^{17}		671						
	10^{18}		669						
	10^{19}		668	39		40.5	314		
	10^{20}		669						
	10^{21}		667						
	10^{22}		668						
	10^{23}		669						
	10^{24}		669				317	317°F	
AVER			669		12.79				
4	10^{31}	T OPEN S 35.42° BEFORE DEAD CENTER	634				318		
	10^{32}		634						
	10^{33}		633						
	10^{34}		632						
	10^{35}		633	39		38	317		
	10^{36}		632						
	10^{37}		631						
	10^{38}		633						
	10^{39}		634						
	10^{40}		635				319	320°F	
AVER			632.7		12.05				
5	10^{45}	T- 14.34° PAST OPEN S- 16.10° BEFORE DEAD CENTER	657				333		
	10^{46}		655						
	10^{47}		655						
	10^{48}		654						
	10^{49}		654			33.2	330		
	10^{50}		656						
	10^{51}		655						
	10^{52}		654						
	10^{53}		656						
	10^{54}		656				331	309°F	
AVER			655.1		12.51				
6	10^{59}	T- 14.34° PAST OPEN S 22.34° BEFORE DEAD CENTER	677				333		
	10^{60}		678						
	11^{01}		678						
	11^{02}		679						
	11^{03}		677	39		34.1	331		
	11^{04}		679						
	11^{05}		678						
	11^{06}		679						
	11^{07}		677						
	11^{08}		678				330	311°F	
AVER			678		12.95				
7	11^{15}	T- 14.34° PAST OPEN S. 28.98 BEFORE DEAD CENTER	687				337		
	11^{16}		687						
	11^{17}		686						
	11^{18}		685						
	11^{19}		684	39		35	339		
	11^{20}		684						
	11^{21}		683						
	11^{22}		683						
	11^{23}		684						
	11^{24}		684				340	310°F	
AVER			684.7		13.08				
8	11^{30}	T 14.34° PAST OPEN S- 35.42° BEFORE DEAD CENTER	655				342		POUNDING
	11^{31}		655						
	11^{32}		654						
	11^{33}		653						
	11^{34}		648 missed ignition						
	11^{35}		654	39		33	342		
	11^{36}		653						
	11^{37}		655						
	11^{38}		654						
	11^{39}		655				344	325°F	
AVER			654		12.48				
9	11^{43}	T-14.34° PAST OPEN S-41.65° BEFORE DEAD CENTER	610				350		BAD POUNDING
	11^{44}		611						
	11^{45}		610						
	11^{46}		609						
	11^{47}		608	39		32	352		
	11^{48}		608						
	11^{49}		607						
	11^{50}		606						
	11^{51}		607						
	11^{52}		606				357	330°F	
AVER			608		11.60				
10	1^{10}	T- 14.34° BEFORE OPEN S- 16.10° BEFORE DEAD CENTER	580				296		
	1^{11}		580						
	1^{12}		579						
	1^{13}		578						
	1^{14}		579	39		33.4	298		
	1^{15}		579						
	1^{16}		578						
	1^{17}		580						
	1^{18}		579						
	1^{19}		578				300	298°F	
AVER			579		11.06				
11	1^{25}	T- 14.34° BEFORE OPEN S- 20.98 BEFORE DEAD CENTER	604				300		
	1^{26}		605						
	1^{27}		605						
	1^{28}		606						
	1^{29}		605	39		35	300		
	1^{30}		606						
	1^{31}		605						
	1^{32}		606						
	1^{33}		605						
	1^{34}		605				302	305°F	
AVER			605		11.56				

(b) The combination of throttle and spark advance to give highest speed now being known, a series of tests were made with throttle and spark set at the above points and the amount of compressed air forced onto the cylinder varied, thus changing the temperature of the cylinders. It was found that the efficiency of the cooling apparatus had a marked effect on the Horse Power developed and also on the time of ignition to give greatest speed. With the compressed air entirely shut off the temperature of the cylinder rose and the time of ignition to give greatest H.P. was found to be 19.32° before dead center or notch 3-3/8, as compared with 28.98° with compressed air valves wide open; the Horse Power was decreased from 13.08 to 11.42. The Horse Power and time of ignition steadily increased as more compressed air was turned on. These tests show the absolute necessity of good cooling and accompanying loss of power if the cylinders become at all heated.

(c) A series of tests were taken with the throttle and spark advance set at the points found to give greatest speed and the setting of the atomizer adjustment screw (see pp. 7) varied. Tests were taken with this screw in six different positions, and the position which gave greatest power recorded.

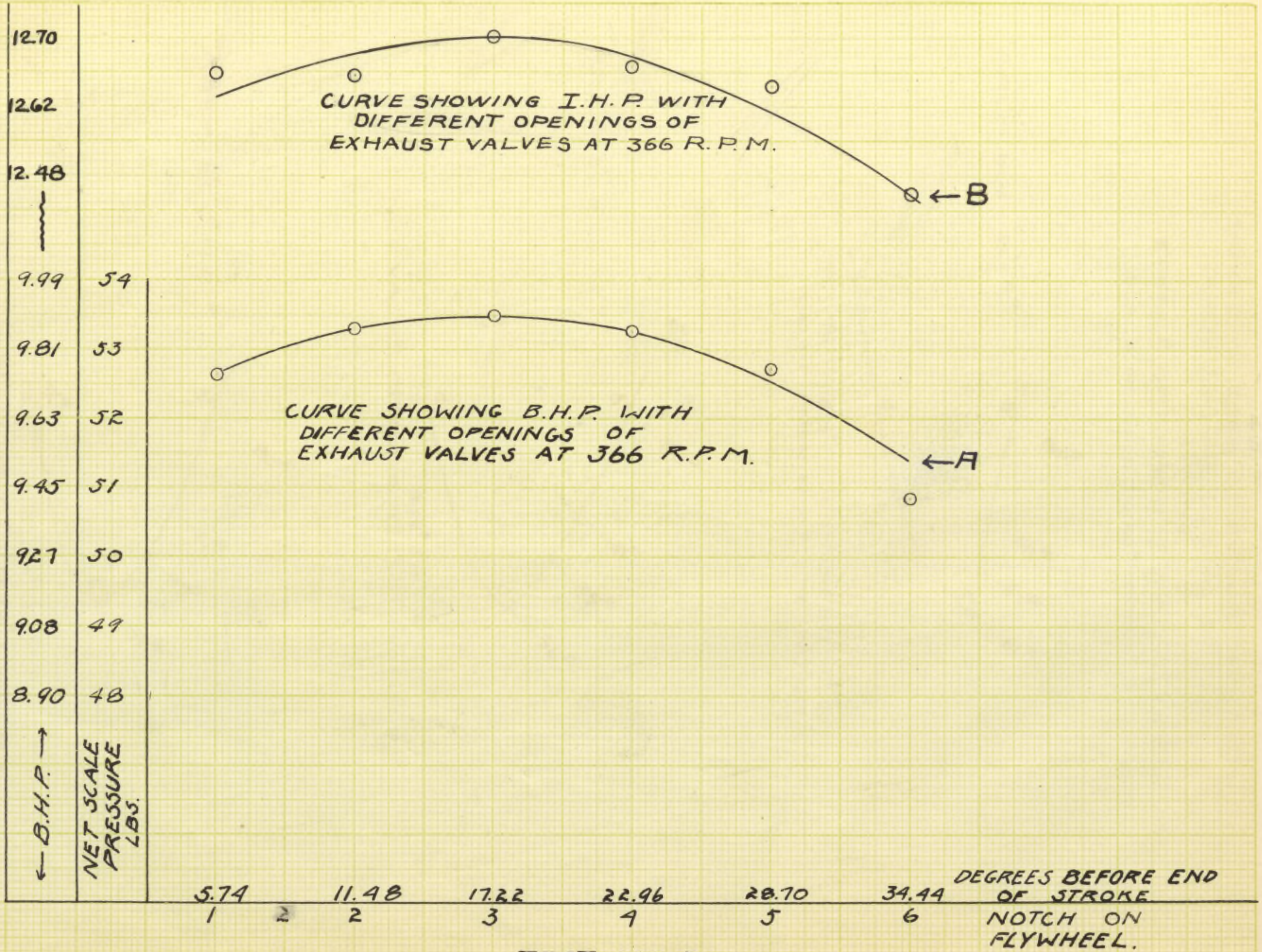
Comparing this position of the adjustment screw with that found in (b) Test I, we were surprised to see that the screw was opened b t one division more at the low speed than at the high speed. We had expected that a much richer charge would be necessary at slow speed for maximum power than at high speed, and did not see the reason for this apparent contradiction until Test No. IV was taken (see pp. 32). Here it was seen that at slow speeds a considerably greater amount of gasoline was drawn off the atomizer nozzle than at high speeds, thus satisfying the conditions known to be true, that is, a rich charge for power at slow speeds and a comparatively poor charge for high speeds. This shows that the Knox atomizer is correct in its action, giving better service even than a carburetor which would give an absolutely constant richness to each charge.

TEST NO. III.

Proper Time of Opening of Exhaust Valves.

(a) Six sets of exhaust valve cams were made of cast iron, and each set was carefully ground so as to give a different time of opening of the exhaust valves, keeping the closing of the valves always on dead center. The throttle and spark advance were set at the points found in Test No. I which gave the maximum power. A number of 20 minute tests were taken with each set of cams. The results and best time of opening of exhaust valves may be seen by a glance at the following curves. Indicated horse power was also computed for each of these tests and the results may be seen from curve (B). The best point for the exhaust valves to commence opening at low speeds is seen from curve (A), pp.28 to be at 20° before end of stroke = notch 3-1/2 on fly wheel. Curve (B) shows the I.H.P. computed from the indicator cards (see Test I, pp.17). This curve agrees with curve (A) fairly well, but owing to faults in the reducing mechanism and hot indicators, the I.H.P. computed was liable to considerable error. However, the B.H.P. taken from the engine shaft as shown in curve (A) is an accurate means of determining the proper point for the exhaust valve openings.

On pp.29 are shown samples of the indicator cards taken during the above tests. The effect of early opening of the exhaust valves can be seen on the indicator cards by the rounding of the toe of the card and the lowering of the lines bc and cd. The lowering of line bc showing less forward pressure of the expanding gases near the end of the explosion stroke, and the lowering of the line cd less back pressure during the first part of the return stroke. The proper point for the opening of the exhaust valves should give a card whose net area was greater than that of cards taken with any other time of opening.

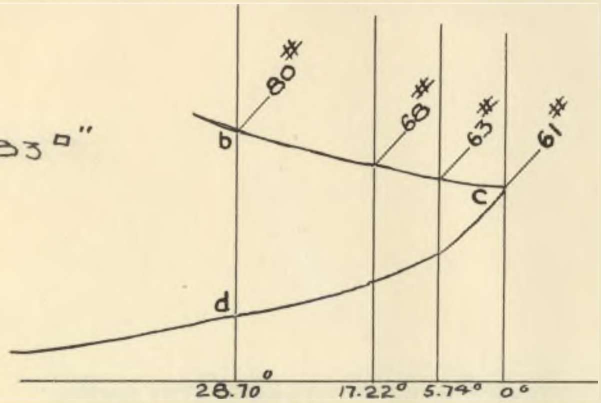


12.70
12.62
12.48
9.99
9.81
9.63
9.45
9.27
9.08
8.90
54
53
52
51
50
49
48
← B.H.P. →
NET SCALE PRESSURE LBS.
CURVE SHOWING I.H.P. WITH DIFFERENT OPENINGS OF EXHAUST VALVES AT 366 R.P.M.
← B
CURVE SHOWING B.H.P. WITH DIFFERENT OPENINGS OF EXHAUST VALVES AT 366 R.P.M.
← A
5.74
11.48
17.22
22.96
28.70
34.44
DEGREES BEFORE END OF STROKE
1
2
3
4
5
6
NOTCH ON FLYWHEEL.

TEST NO. 3 (a)

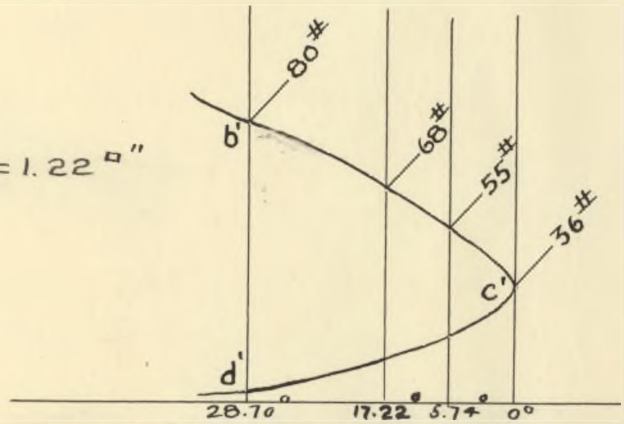
SAMPLE OF TOES OF INDICATOR CARDS
TAKEN DURING TEST NO. III (a).
SHOWING
EFFECT OF EXHAUST VALVE OPENING.
SCALE REDUCE TO 60# SPRING & L = 8.82"

AREA bcd = .83 □"



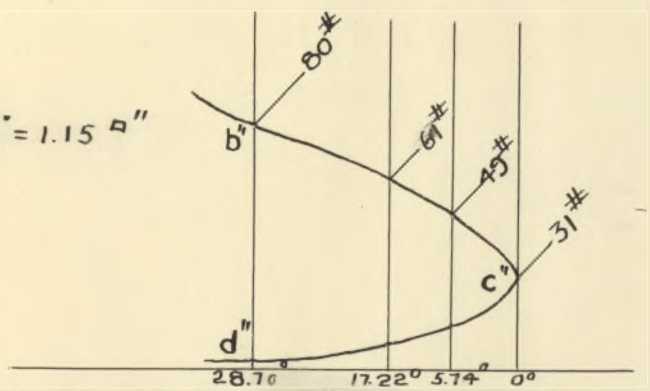
VALVE OPENIN AT 5.74° = NOTCH I.

AREA b'c'd' = 1.22 □"



VALVE OPENING AT 17.22° = NOTCH 3.

AREA b"c"d" = 1.15 □"

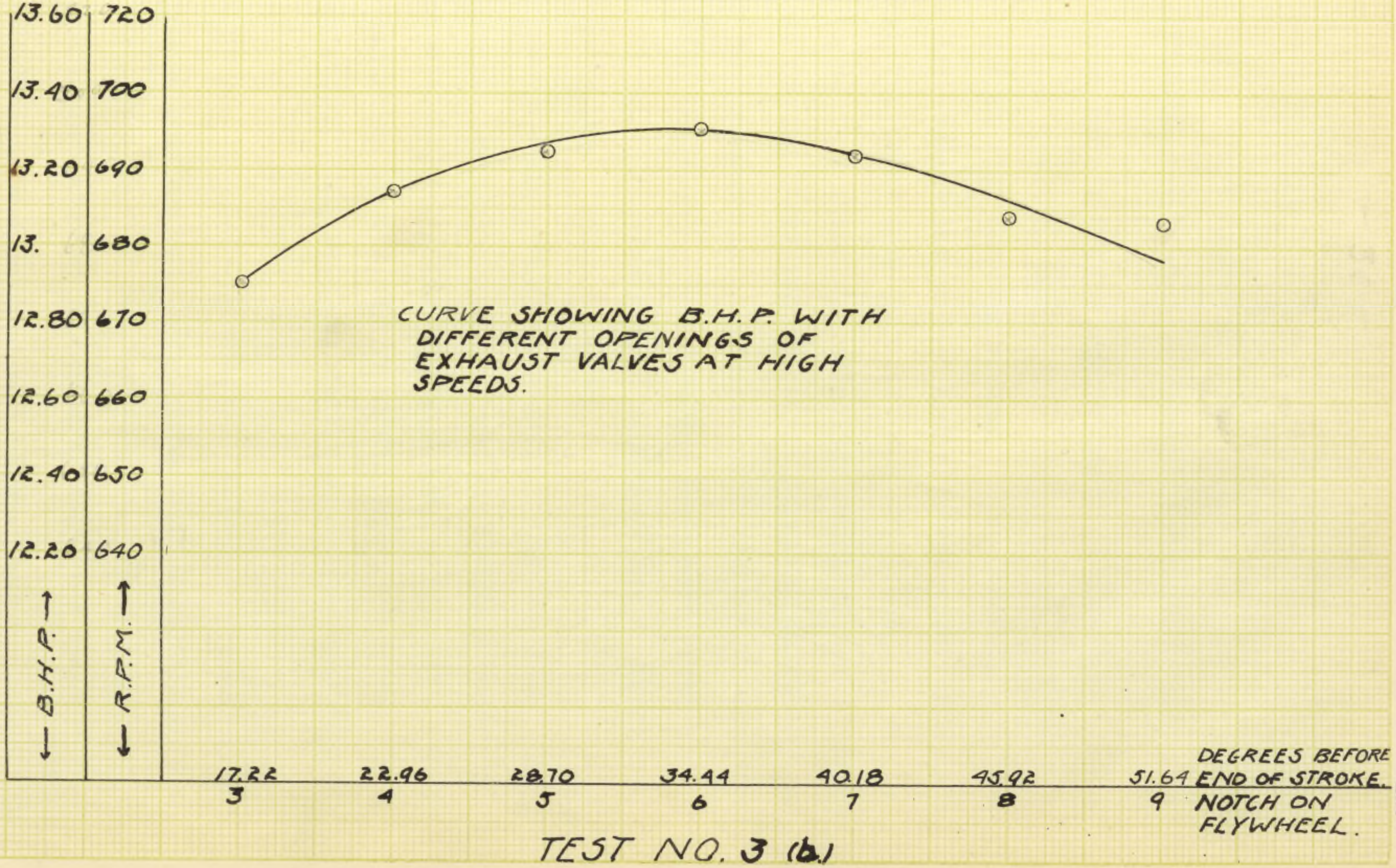


VALVE OPENING AT 28.70° = NOTCH 6.

(b) The throttle and spark advance were set at the points for highest speed as determined in Test II and a number of 20 minute tests taken with each set of exhaust valve cams as in (a) Test No. III. Indicator cards could not be taken at these high speeds, hence B.H.P. alone must determine the best time of opening of the exhaust valves. The following curve shows the speeds attained and the horse power developed with each set of cams. It is seen that 34.44 degrees, before dead center, of crank pin travel is the proper time for the exhaust valve to start to open. This corresponds to notch 6 on rim of fly wheel.

Comparing this result with that found in part (a) of this test, we see that for low speeds the valves should commence opening at 20° before end of stroke = notch 3-1/2, compared with 34.44° before end of stroke = notch 6, for high speeds. Hence the valves should be set to commence opening at a point between these two limiting positions, preferably nearer the point found for high speeds.

These results might have been foreseen, for high speeds would cause greater back pressure against the piston during the first part of the exhaust stroke, due to the rush of gas through the exhaust valve, than would low speeds. This necessitates earlier opening of the exhaust valves for high speeds.



13.60
13.40
13.20
13.
12.80
12.60
12.40
12.20
720
700
690
680
670
660
650
640
B.H.P.
R.P.M.
CURVE SHOWING B.H.P. WITH DIFFERENT OPENINGS OF EXHAUST VALVES AT HIGH SPEEDS.
17.22
22.96
28.70
34.44
40.18
45.92
51.64
3
4
5
6
7
8
9
DEGREES BEFORE END OF STROKE.
NOTCH ON FLYWHEEL.
TEST NO. 3 (b.)

TEST NO. IV.

Richness of Charge at Different Speeds.

(a) A series of six thirty minute tests were made to determine the amount of gasoline per intake at different settings of the throttle and at high and low speeds. The throttle was opened to its full extent and enough pressure put upon the Prony Brake to bring the speed down to less than 350 R.P.M. Ran thirty minutes at this speed and noted the exact number of revolutions of the engine shaft and the exact gasoline consumption. Now released the pressure on the brake until the R.P.M. was over 600 and repeated the test. Repeated the two above tests with the throttle at 14.34 degrees before full open and at 14.34 degrees past full open. (See pp. 12).

The following table gives the results of these tests, the amount of gasoline per intake being found by dividing the total gasoline consumption during the thirty minute test by the total number of revolutions of the engine shaft, there being one intake per revolution. By study of this table it is seen that the richer charge is obtained at the low speeds and also that thecharge is poorer in gasoline when the throttle is past open than when open or just before open. This fact seems to agree with the results obtained in (a), Test No. II, which gives a maximum speed at the position of throttle where the poorest charge is obtained. (Also see (c), Test No. II.)

TABLE SHOWING
RESULTS OF TEST NO IV

THROTTLE SETTING	14.34° BEFORE OPEN		OPEN		14.34° PAST OPEN	
R.P.M.	328	612	338	643	387	624.
TOTAL REVOL.	9864	18376	10168	19312	12012	18772
GASOLINE CONS.	59 oz.	106 oz.	66 oz.	117 oz.	65 oz.	116 oz.
" PER INTAKE	.005981	.005768	.006481	.006057	.005402	.005180

TEST NO. V.

Effect of Increasing Compression.

The compression was increased by placing a 1/2" brass bushing between the connecting rod and the crank pin, thus forcing the piston 1/2" further back into the cylinder. From measurements taken on the indicator cards, the compression was increased from 52 pounds to 65 pounds (taken at 360 R.P.M., cylinder warm).

(a) The throttle and spark advance were set at the points found found to give maximum power at 366 R.P.M. (see Test No. I) and a number of tests were taken to determine the increase in B.H.P. due to increased compression. (Exhaust valves opened same as in Test No. I.) The average B.H.P. delivered was 11.25, an increase of 13.5 per cent. Pounding due to overheating took place, however, and it was found impossible to cool the cylinders under the conditions indoors with this increased compression.

(b) An outdoor test was made after the completion of all the other tests with this increased compression and it was found that the cylinders did not become sufficiently overheated to cause harmful pounding at high speeds, but that the cylinders did overheat on a long hill climb at slow speed when full power was needed.

Here again, we see the absolute necessity of good cooling, as a great increase in power could be obtained by increasing the compression, if the cylinders remained fairly cool.

GASOLINE AND CYLINDER OIL ANALYSES.

Oils.	Flash Point.	Specific Gravity at 28° C.
Valvoline	419° F.	.862
Standard Gas Engine Oil	458° F.	.905
Gasoline		.703

Although the Valvoline does not have as high a flash point as the Standard Gas Engine Oil, it proved to be more satisfactory, probably because it is thinner and does not have the tendency to gum that the heavier oil has.

DISCUSSION OF TESTS AND CAR.

From actual experience with the Knox Air Cooled System we know that it is a success and cools the cylinders sufficiently to insure good lubrication and yet not to such an extent as to reduce the thermal efficiency of the engine, which is often the case with water cooled motors. The draft caused by the movement of the machine itself is of great importance in the proper cooling of the cylinders. This was seen by the difficulty experienced in keeping them cool while testing, when stationary, even with the aid of the compressed air apparatus described on page 10. But the draft alone is not sufficient for the proper cooling as overheating will occur, if the fan belts are removed or are so loose as to allow the belt to slip.

The valve seats as they are made on this car are troublesome. If the cylinder ever becomes greatly overheated from lack of lubrication or other causes, the valves are apt to become warped and loss of compression is the usual result. A good quality of asbestos woven wire packing was used on a valve seat in this condition and found very satisfactory, if care was taken to tighten the valve binding bolt after the engine was started and the packing was subjected to heat.

There is no doubt that the oiling system used on this car could be improved, the hard grease cups on the extremities of the main shaft requiring too close attention and neglect causing a burnt bearing. Platinum is carried from one point in the make and break to the other and a reversal of the direction of the current before a new set of points becomes necessary would often save replacement. The atomizer was discussed in Test IV, and proved satisfactory with the following exception- that this style of atomizer often requires priming before starting the engine, especially in cold weather. The spiral gears seem to wear down in a remarkably short time, probably due to dust and improper lubrication. The springs on the Knox Car are as remarkable for their carrying capacity as for their easy riding properties. The lever steer is best suited for good roads. It allows quick action and for that reason is well adapted for city use. How, ever, this control is tiring and rather unsteady on rough roads or at high speeds.

After the car was taken outside, the throttle and spark advance were connected to separate levers- the throttle being controlled by the same lever as before and the spark advance by a separate lever. It was found that for use on the level city pavements, where moderate speeds and little power was required, the engine could be run with the throttle almost closed and the spark advance varied to give any small change in speed. The quiet running of the engine under this control was remarkable accompanied by a decrease in gasoline odor emitted from the muffler. Also when power or speed was required, the operator could change the relative positions of throttle and spark advance to give best results as judged by the actual performance of the car.