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Leary

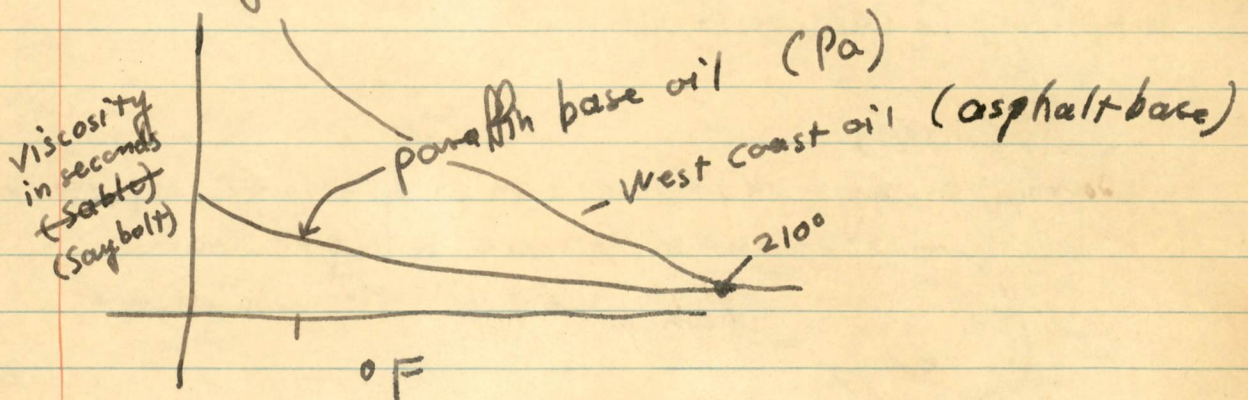
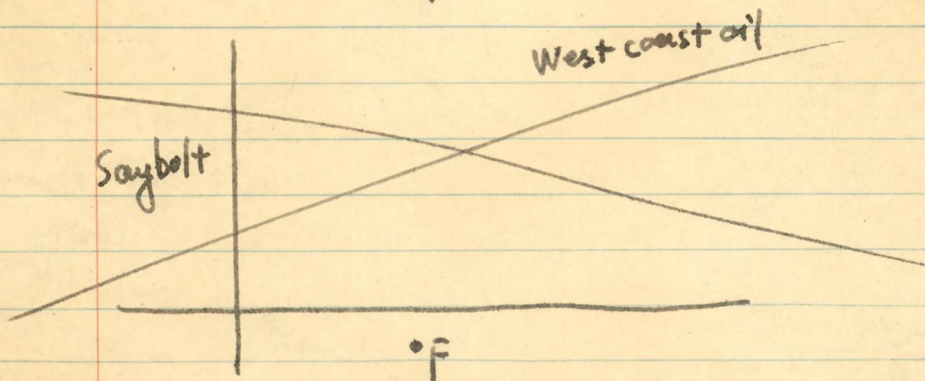


Lubricating oils. Chemistry much more complicated than fuels, unknown.

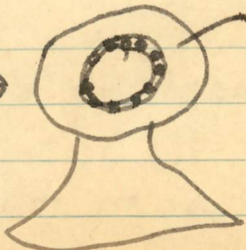
Properties lub. oil should have for internal comb. engine.

- 1) Chemically inert
 - 2) Lack volatility
 - 3) Small viscosity change with temperature
- #3 the most important.

Def.: Viscosity is the resistance to flow.



Why #3 is important

1000 μ M $\rightarrow$  $140^{\circ}F$. but when it gets ~~hotter~~ hotter, oil gets thinner, film of oil on which all bearings are floating metal comes in contact, friction, heat, expansion, mess.

Castor oil the best known so far. Not a "mineral" (i.e. mined) oil. Used by racing cars. But it is not chemically inert.

enough, forms sludge. Like all vegetable oils, harder on parts than mineral oils.

Arbitrarily call asphalt 0, paraffin 100

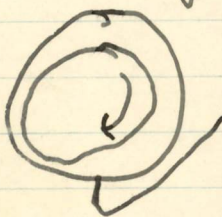
arbitrary formula: Viscosity of oil $x = \frac{A-x}{A-B} \cdot 100$

A is asphalt, B is paraffin (??)

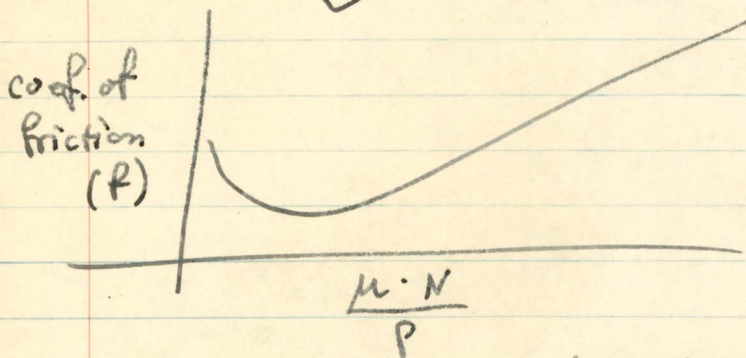
You want the thinnest oil that will keep film. Summer & winter changes. Paraffin oil contains wax, which is usually removed, but if not, it solidifies in cold.

Bearings

Journal bearing - or if it can pump enough oil into pt. of minimum clearance to keep it clear



neckline - starting when there is no oil here.



N = RPM of shaft
 P = load on bearing
 μ = viscosity

coef. of friction = $\frac{\text{dragging force}}{\text{load}}$ (or force of friction)

If P = force of friction = μN

So pressure on bearing has nothing to do with heat. (Safe load is inversely prop. to RPM) Ball & roller

bearings increase friction tremendously. - never use 'em unless you have to. Ball & roller bearings melt when lubrication fails, things rotts, you stop engine, nothing harmed. Friction: no lub, 1; mineral oil, $\frac{1}{2}$; vegetable oil, $\frac{1}{4}$; but veg oil makes so much sludge. Ball - 1; roller, $2\frac{1}{2}$; plain bearing - 3:

pump. - ~~not~~ attached to throttle, so when it opens it throws gas into air temporarily.

When engine is idling, suction gets so small gas is not sucked, so how to get rich mixture? Run pipe from gas line to above throttle, with appropriate valves. - idling nozzle or orifice.

But this carb. fails to atomize gas. Put in "air bleed" - pipe from air to gas pipe just below nozzle, this atomizes.

OK for auto, but as plane goes up, mixture gets richer - you get some suction no matter what air density is - so it will suck as much gas in, but air density being less, mixture will be richer. So put a valve up in pipe, manual control. This only works up to 25,000 ft.

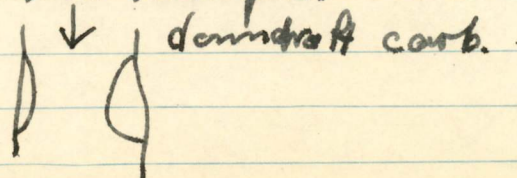
Or else control amount of fuel - by putting air connection onto tank, adjusting pressure on it.

Choke - in cold weather start with ~~throttle~~ ^{throttle} wide open - stop the flow of air with choke to enrich mixture.

(Carburetors vaporize very incompletely. Monifold is full of puddle of fuel, about 50%, it is blown in blobs into cylinders, hot walls vaporize them & it is ok, if there is no more than 50%. Sometimes put jacket around main pipe, run exhaust thru it, heat it up to speed evaporation - but only use it at beginning, do not keep it up, or air will get too thin.

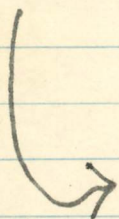
Region of venturi is cool, evaporation. If it gets too cool, & air is humid, & gas makes it so, venturi throat will ice up, stop motor. To avoid this carb has been revamped.

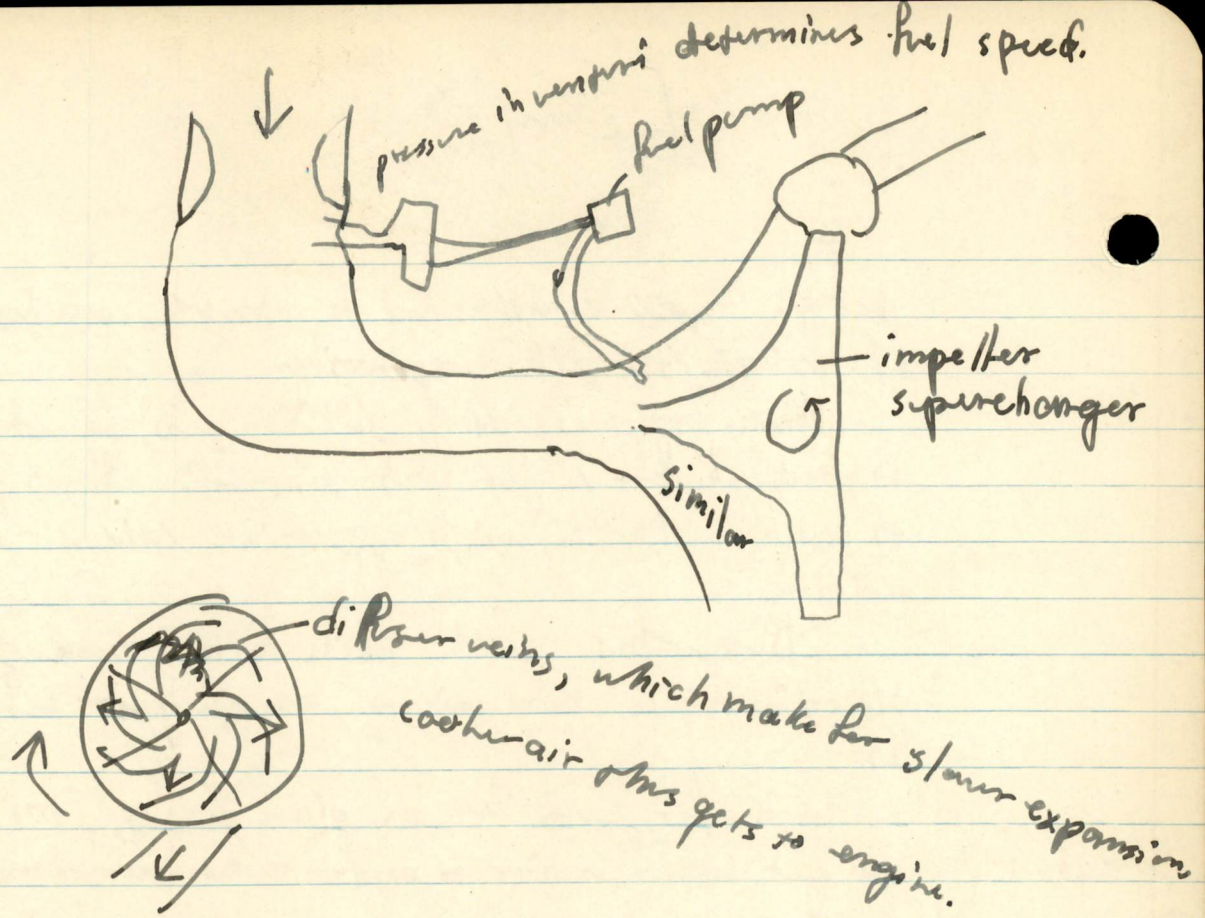
Injection carb.



only air goes thru this venturi

How about
pressure on tank?





Carburetors a big, specialized, field.

Leary Dec. 10

Carburetors. Details in book - general principles here.

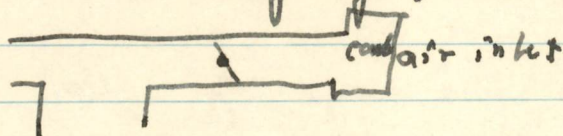
Purpose - a) Vaporize fuel b) Mix air & gas. properly.

by weight $\frac{F}{A}$ must lie in range $\overset{\text{lean}}{.065} - \overset{\text{rich}}{.12}$

(garage mechanic looks at it $\frac{A}{F}$ 17 to 1 - 8 to 1)

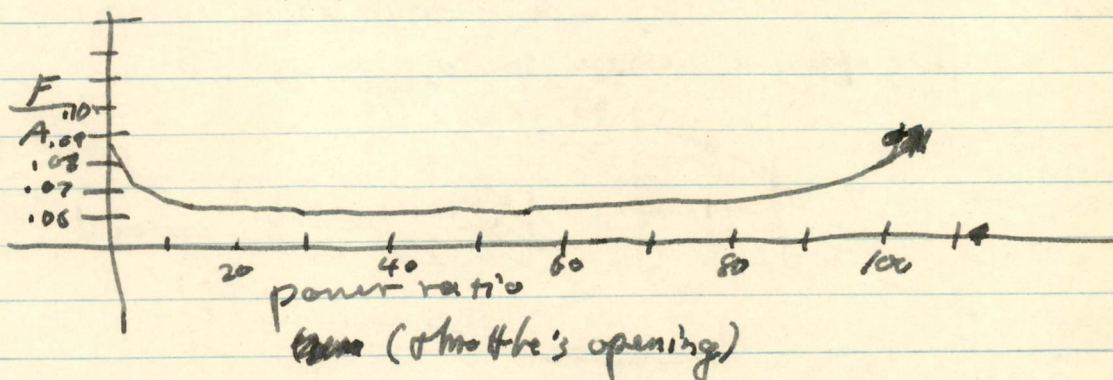
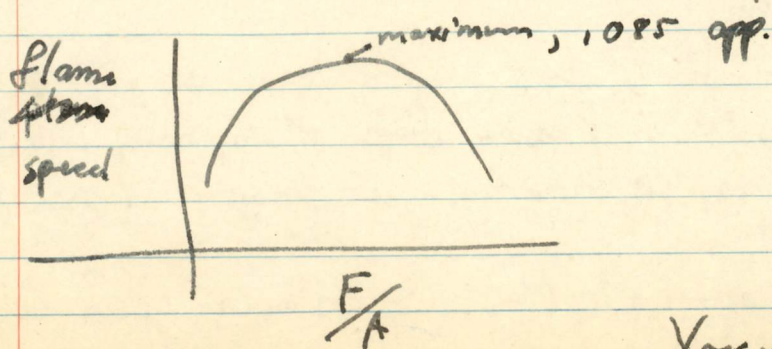
Often hand control of mixture in plane.

When idling engine, must run rich.



4% residual, full throttle, is 4% of incoming charge. When throttle is closed, less fresh mixture, or leaner, you can get up to 20% residual. When idling throttle is closed, so mixture must be richer.

Function #1, - Supply richer mixture at idling



You enrich mixture at full

power output to get max. flame speed.

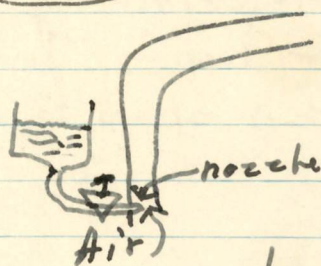
Function #2. A rich mixture at full power.

" #3. Must supply best economy mixture in cruising range.

Generally run mixture a little richer than tests show, for safety. Too lean mixture pops back. Also hard on exhaust valves - too hot. Too rich mixture deposits carbon all over, & wastes gas. Also flame speed is low in lean mixture. - it may be still burning when new mixture comes in, ignite it, flashback (back fire)

If heat is not all converted into work, cylinders get hot, must be cooled. - & lean mixture is not cooling.

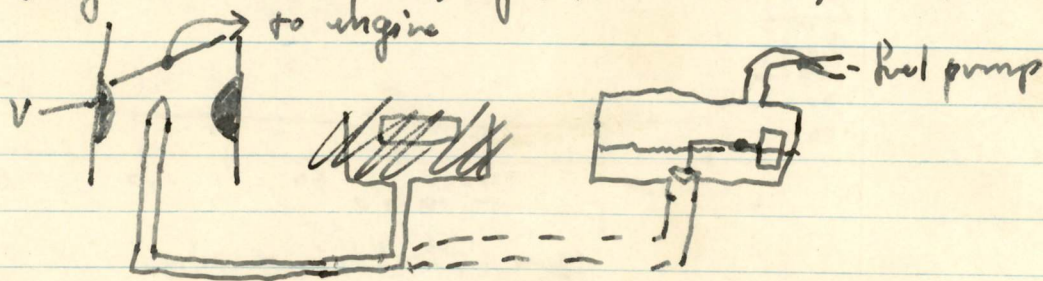
Why throttle? Why not just change $\frac{F}{A}$ ratio? Because you cannot change it enough. (Diesel can run on .01 mixture)



This is an elementary carb.

But as tank level fell mixture would get leaner.

Use 2 tanks, with float valve in lower one, to solve. But if you increase speed, gas is still same, air double. So junk it.



Not pressure of fuel, but suction of air at jet sucks out fuel. Venturi is "V". Pressure drops there, oddly enough you get partial vacuum, so normal air pressure on gas pushes it up.

Step on gas, open throttle, air rushing in, gas not quite so fast, mixture would be temply too lean. So, must accelerating

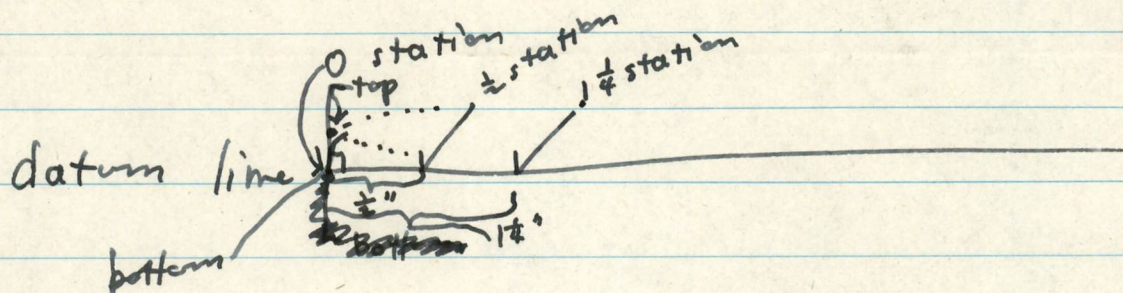
Harn, Dec. 8

Top measure - 30", leading to trailing edge
Front spar - $\frac{3}{4}$ " wide, its center 3" from front.
Front spar happens to come on station mark, back not.
Keep ruler at rt. L, for measurements.
Radius measurement not used till wing is finished.

Aeromechanics class Nov. 10, '42

Aeromechanics class Nov. 10, '42

Station	Bottom	Top
0 	 	



Some datum lines are in ~~the~~ between bottom & top, but most are underneath both.

Figures given in decimals of inch. Straight line distance from leading to trailing edge of wing is the chord. NACA figures are based on 1" chord. Change decimals to nearest $\frac{1}{64}$ " - by decimal equivalent table.

Air lines long subsidized by gov. - with air
mail contracts.

Hann, Nov. 17

85% pull from top, 15% push from below
(i.e., 85% thinning of upper air, 15% ~~thinning~~ thickening lower air)

(~~Obsolete~~
Obsolete
military
weapons are
scrapped -
why not
obsolete peace
time capital?)

Will continue using wood, which has some strength weight as

steel. All engines have dual ignition systems, ^(sparkplugs) for safety.

Ordinates for Clark-Y wing

Stations	Bottom	Top
0	.0350	.0350
.0125	.0193	.0545
.0250	.0146	.0650
.0500	.0093	.0790
.0750	.0063	.0885
1.0000 , 1.000	.0042	.0960
.1500	.0015	.1068
.2000	.0003	.1136
.3000	.00	.1170
.4000	.00	.1140
.5000	.00	.1052
.6000	.00	.0915
.7000	.00	.0735
.8000	.00	.0522
.9000	.00	.0280
1.0000	.00	.0012

Radius .0150 (to prevent front of wings being pinched)



500.	9010.
88	88
513	8906
088	

$$\begin{array}{r} 10. \\ \hline 529. \\ 1.635 \end{array}$$

$$\begin{array}{r} 5 \\ \hline 635 \\ 9049 \end{array}$$

Hann Nov. 17

(2)

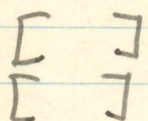
30" chord, Clank X

Stations		Bottom		Top	
0		1.0500	$1\frac{3}{64}$	1.0500	$1\frac{3}{64}$
.3750	$\frac{3}{8}$ "	.5790	$\frac{37}{64}$	1.6350	$1\frac{1}{8}$
.7500	$\frac{1}{2}$	.4380	$\frac{7}{16}$	1.9500	$1\frac{51}{64}$
1.5000	$1\frac{1}{2}$	.2790	$\frac{9}{32}$	2.3700	$2\frac{3}{8}$
2.2500	$2\frac{1}{4}$	.1890	$\frac{3}{16}$	2.6550	$2\frac{51}{32}$
3.000	3	.1260	$\frac{1}{8}$	2.8900	$2\frac{7}{8}$
4.5000	$4\frac{1}{2}$	.0450	$\frac{3}{64}$	3.2040	$3\frac{13}{64}$
6.0000	6	.0090	$\frac{1}{64}$	3.4080	$3\frac{13}{32}$
9.000	9	0	0	3.5100	$3\frac{33}{64}$
12.000	12	0	0	3.4200	$3\frac{27}{64}$
15.000	15	0	0	3.1560	$3\frac{5}{32}$
18.000	18	0	0	2.7950	$2\frac{7}{8}$
21.000	21	0	0	2.2050	$2\frac{13}{64}$
24.000	24	0	0	1.5660	$1\frac{9}{16}$
27.000	27	0	0	.8400	$\frac{27}{32}$
30.000	30	0	0	.0360	$\frac{1}{32}$

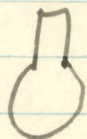
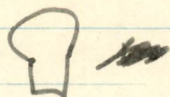
radius $\rightarrow$.4500

Width of pencil mark is wide enough so we can disregard $\frac{1}{100}$ s, & even bigger.

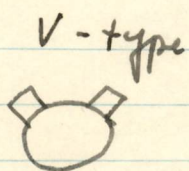
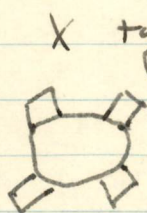
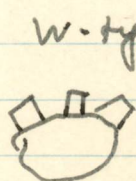
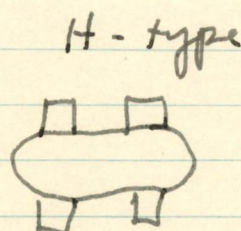
Further classification by cylinder arrangement.

 opposed cylinder motor

Upright & inverted motors



all set
in banks -
in lying motors



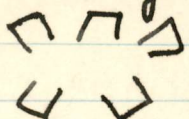
radial. 3, 5, 7, or 9 cylinders All uneven no.s, to maintain
4-cycle principle - this is impossible with even no. of
cylinders 1, 3, 5, then 2, 4, 6, then (I do not get it)

Diesel ignites not - depends on compression to heat principle. Expanding gas takes up heat. Compressing gas emits heat - & Diesel compresses it till it is hot enough to burn.

Diesel will burn even milk (casein burning) anything that will oxidize may be burned in a diesel.
2 cycles more common in diesel

Sweeney Nov. 12

Maxim - early experimenter. Rich Englishman. Steam engine, with 48,000 gas jets. Weighed 8 tons. 1st steel tube fuselage - 105' wingspan. Success in his grasp - then he quit.

Langley, sec. of Smithsonian inst. Aerodynamic research at U. of Pa. 400 yd. flights with models, 1890. \$50,000 from Congress to build big one. Manley built engine - the radial engine  Liquid cooled.

Crankshaft is what turns reciprocating motion to circular. Radial crankshaft is something special. Later the French built rotary motor. - went out with world war, radial continued.

Langley - Manley failure, 1898, press ridicule, he d.
1903, Wright bros.

1900 - '14, all motors too heavy. World War retarded aviation 10-15 years

learned about properties of "air foils", or wing tops.
1906 - alloy, corrosion resisting steel discarded. Very high tensile strength 250,000 lb. per sq. inch, opposed to 150,000 in cast iron. Aluminum came along & other alloys - magnesium. Higher compression ratios & lighter motors possible. Fuels, bearings, valves, minute details perfected - increasing power by 50%.

Exhaust turbine superchargers - can get more altitude with them. In it are 3 temp. zones - white heat, normal, & sub-zero, along one 8" rod - good material necessary for this.

Diesel. Originally built to burn coal dust

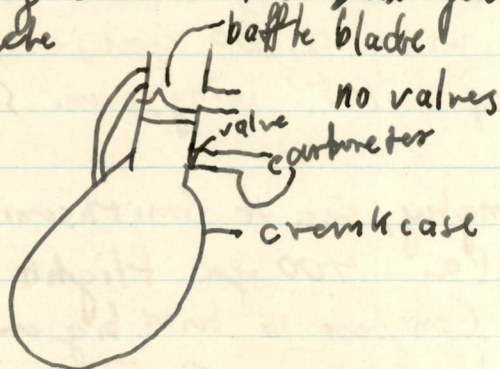
Process

How the gasoline engine works

Internal combustion engine.

Cylinder with piston, connected to crankshaft.

Valve lets gas into cylinder, electric spark ignites it, it drives piston down, moving crank. For ~~gas~~ gas or liquid fuel, not solid. 2 ways 1) 2 stroke cycle

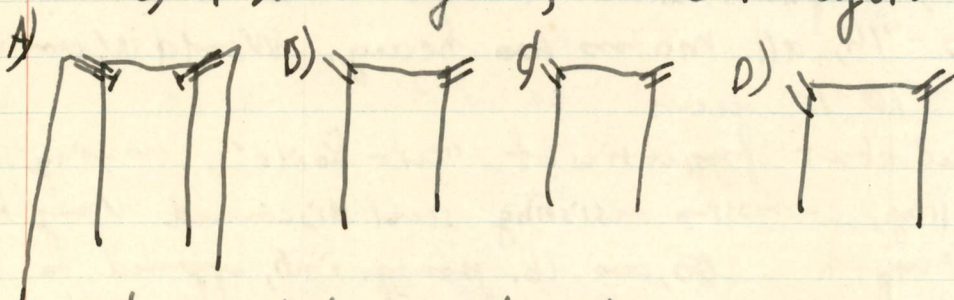


crankcase is air-tight. Charge from carb. to crankcase, then to upper chamber. Never completely successful. Upper chamber not perfectly exhausted. Much fuel is exhausted.

Advantages - 1) Simplicity of design 2) We can operate Diesel on it, using solid fuel. ("Small size power plants" use them only today.)

Outboard motors, small generators, etc. use them.

2) 4 stroke cycle, or Otto-cycle



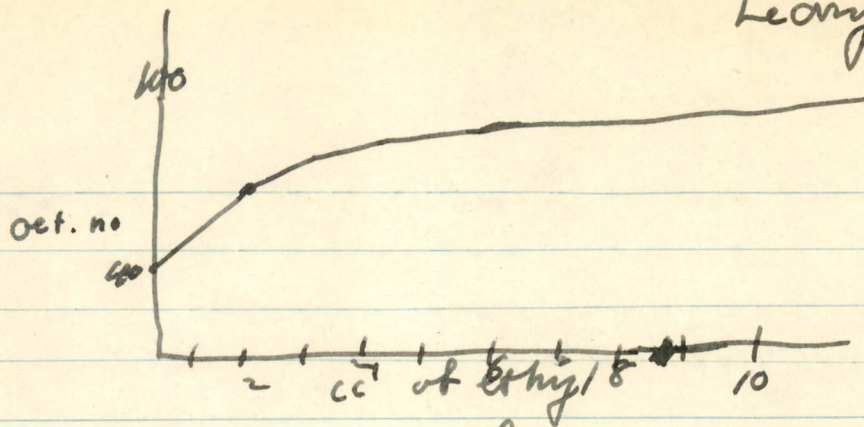
valves in holes, with rocker arms

A) Piston left opens, allows gas. Then piston goes up, both valves closed. Charge is ignited when piston at "top dead center". Exhaust (right) valve opens, & when piston goes back up, pushes out burnt gases. Only fires every other time piston comes up.

Superior to 2 cycle. E.C. of fuel. Full power. In multiple cylinder motor, they fire alternately (why can't axle be crankshaft?)

Leamy, Dec. 3

3



So extra cc. after 1-2 are ineffective, & corrosion gets bad.

Cracked gasoline not used in airplanes. Low pressure & temp. & superchargers makes it polymerize.

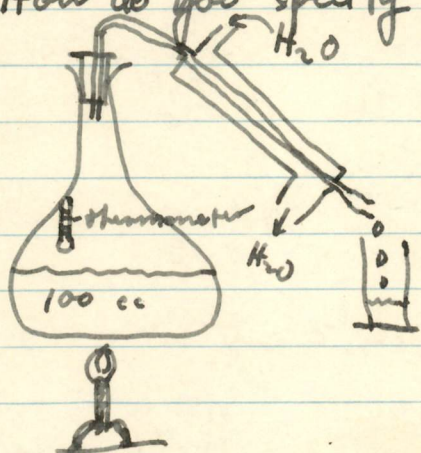
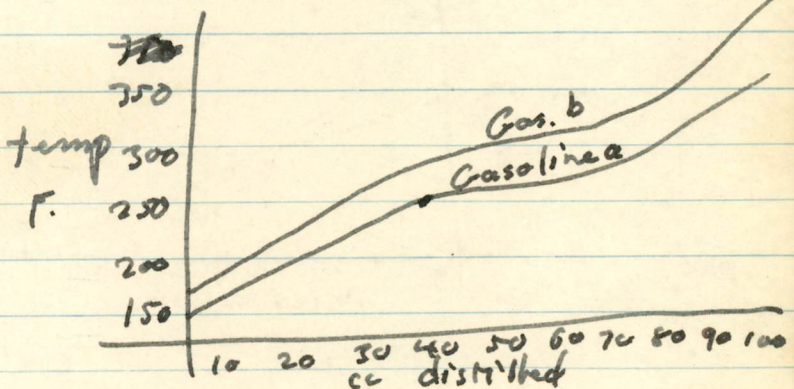
Leamy Dec. 3

2

impossible. Pentane to octane is gasoline, heavier stuff is other things. So you don't know just what gasoline is. You get other series, too. West coast's better gasoline, east lubricants.

In summer, demand's for gasoline, in winter for fuel. So crack molecules by high pressure & temp., to get more gasoline, double gasoline yield - slightly different properties - it won't store, but will run, gumming engine. Better in other respects.

How do you specify types of gasoline? By boiling pt.



a is best for cold weather. Low ^{left} end point, easy starter in cold.
b " " " summer traffic. a will give "vapor lock" - vaporizes in intake pipe. So take high end pt.

Up high, volatile gas is run worse, vapor lock comes due to lower pressure.

High right end pt. is bad - fuel must be volatilized before going into cylinders. If you have manifold feeding cylinders, you may have trouble getting = mixture for each cylinder, not so much in radial; but more if fuel goes into manifold as liquid.

~~Knocking~~
Knocking. "Octane no." is measure of knocking, nothing else. Scale 0-100

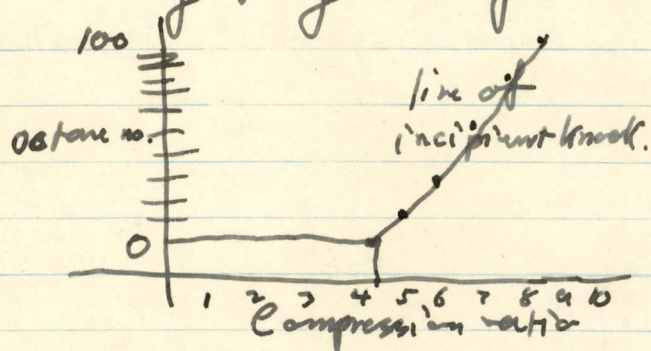
Compression ratios of 4-8 will handle 0-100.

Iso-octane (2,2,4 trimethyl pentane) (\$1.00 per gal.)

Heptane - normal structure

If it takes 70% pure iso. oct. + 30% pure hept. to get same knock as any sample of gas, sample is oct no 70.

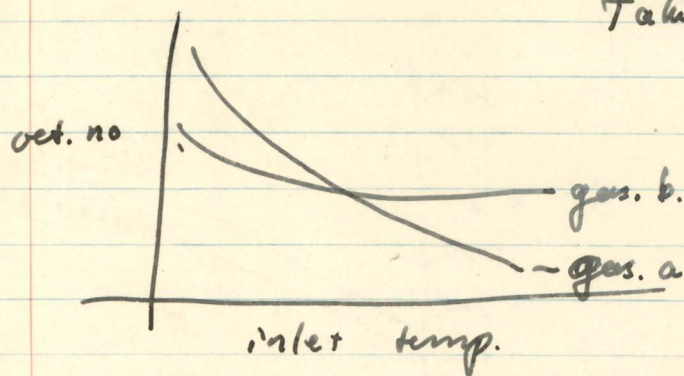
Today they have gas of oct. no. 120.



Get app. octane no. by taking it off the scale.

Not a good method.

Take 2 gas with 70% oct. no.



Raising temp of manifold makes gas knock more (burn too soon more)

So gas with better oct. no. at test temp. might not be best at working temp.

300° F. ok usual test temp, Higher than usual working temp.

Addition of tetra ethyl lead. This raises octane no.

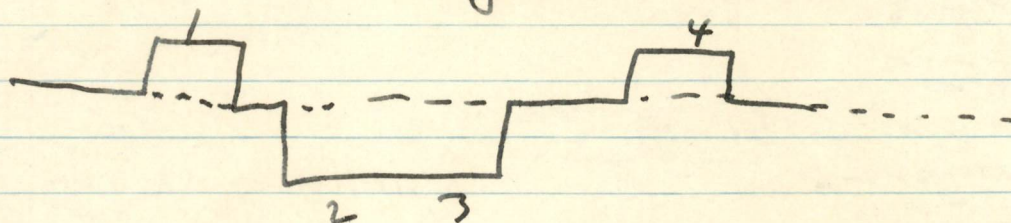
Tends to corrode parts; 1 1/2 cc. per gal. usual amount, 2 advantages offset corrosion, but at more than 1 1/2, trouble.

Add tetra bromide to tetra ethyl lead, vaporizes deposits of corrosion, recently. The more you add, less effective it becomes.

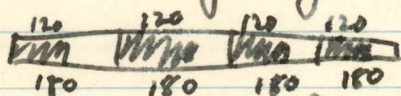
Leary, Dec. 3

Assignment. Ch. 5 & 12
 Pump distribution

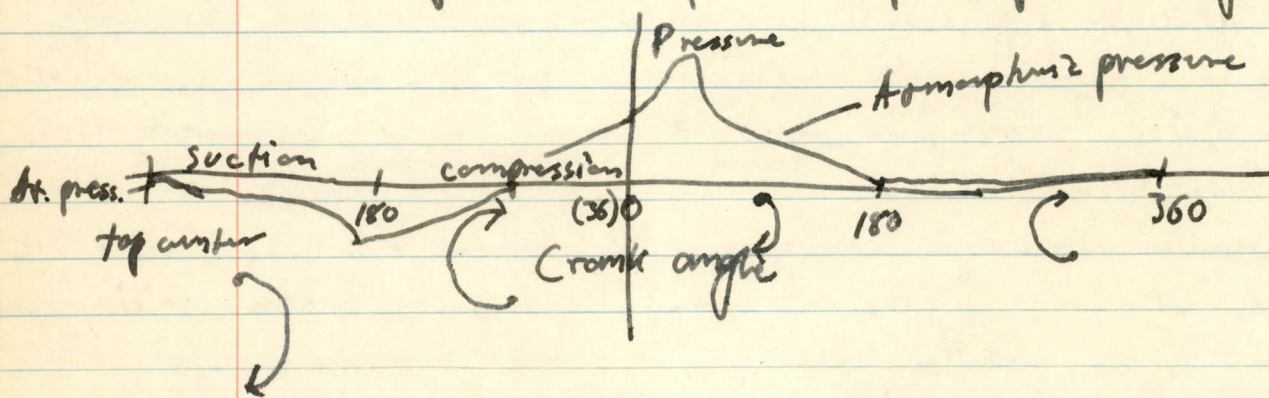
Exhaust valve opens when piston is at bottom, ideally, but actually about 60° before bottom center. Takes time for valve to open, that's why, & back stroke must not be retarded.



a power stroke every 180° But opening valve early means only every 120° .

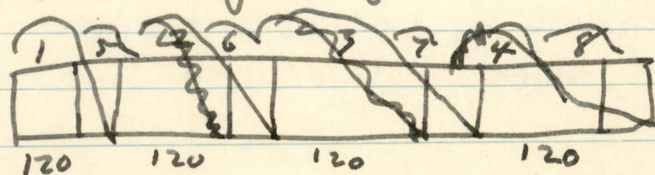


To get rid of power lapses, go to 6 cylinder engine.



a fall in pressure during suction stroke

~~4 cyl. eng.~~ 4 cyl. eng.

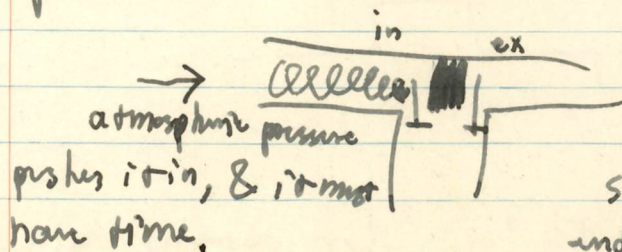


a wavy distribution of power.

So put in 8 cylinders to fill gaps.

So torque or pressure variation is lessened, a smoother engine. - & c., ad inf.

Valve overlap. Ideal engine has only 1 open at time. But high speed engine needs interval of "valve overlap", time when 2 are open at once. Because



similarly, ex. valve, at end of ex. stroke, should be open a little longer than end of stroke.

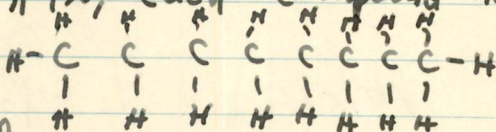
Inlet pressure must be greater than exhaust pr. during overlap, else exhaust will get back into fresh.

Fuels

? U.S., or world?

Available supplies will last 100 years, latest estimate, they keep going up. Hydrogenation of coal yield per ton 5 gals. gas. + coke. Then Shale. Coal good for 5000 years. 62%, previous, U.S. of world's oil, Russia 24%,

Gasoline not a single compound. All hydrocarbons. ^{crude oil} Methane - CH_4 ; C_2H_6 , ethane; C_3H_8 - ^{propane} ~~butane~~; C_4H_{10} - ^{butane} ~~propane~~; C_5H_{12} - ^{pentane} ~~butane~~; C_6H_{14} - ^{hexane} ~~pentane~~; C_7H_{16} - ^{heptane} ~~hexane~~; C_8H_{18} - ^{octane} ~~heptane~~; the paraffin series - $\text{C}_n\text{H}_{2n+2}$. Naphthene series - C_nH_{2n} . Aromatic series - $\text{C}_n\text{H}_{2n-6}$. Also, each compound has many isomers. Octane - Normal



But rearrange molecules, get different qualities of octane. Normal octane knocks, iso-octane does not.

Boiling points are all different - thus ke/s are separated, & distinguished.

-263°F; -129, -37.5, +37.8, 95, 160, 210, 248 for paraffin series. But not all heptane will boil at 210°, purity



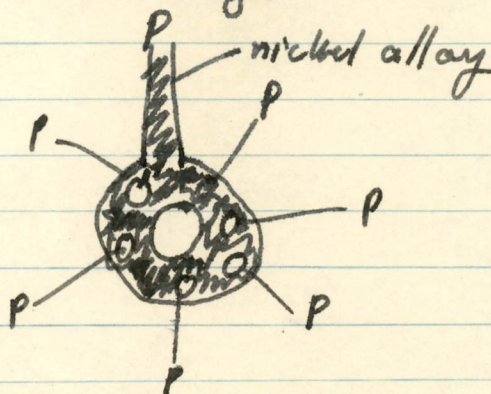
2

Then

120,000 lbs of work in 10 seconds

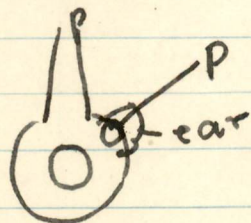
$$\frac{120,000}{550 \times 10} = 21.818 \text{ HP}$$

In radial motor, master connecting rod has holes, in which other connecting rods come, with knuckle becoming fastenings.



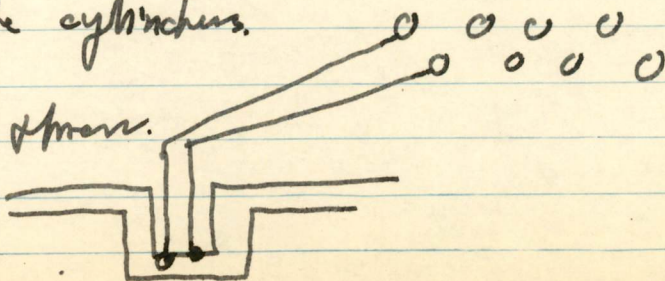
Only one throw thus necessary.

In 2 piston (or 2 row, the "V" engine) just have one master, & one knuckling rod.



Or stagger the cylinders.

Then 2 rods to a throw.



2 notes from RD - silver & Mg.

Crankcase - Aluminium alloy, ^{high strength, with ribs & gussets.} in 2 parts, or more, in radial.

Cylinders anchored to top part of case.

Upper part of case is al., lower part only holds oil & protects rods.

Magnalium - nonflammable, unlike mg. Bottom is made of

Both neck in crankcases today, due to it, as it is lighter.

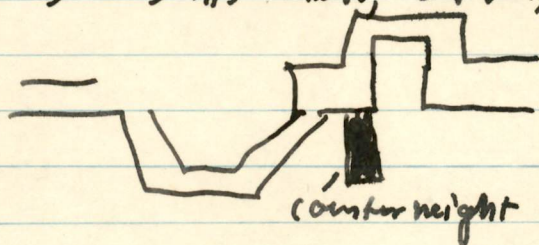
mg. shortage - tech sch.

Hoover vacuum developed Magnalium, air craft banned it. Wheels, no, it. Some on since whenever possible.

Don chemical & its goldmine patents.

Sweeney, Dec. 1

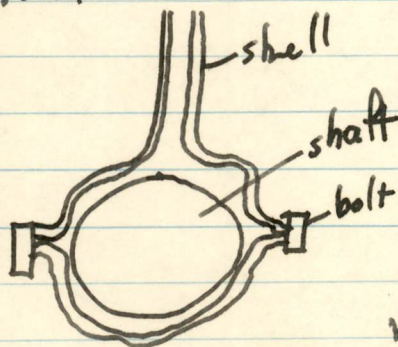
Piston, cylinder, valves all taken care of.
Crankshaft, & method of linking piston rod.
Some shafts whole, others, in radial engines, come apart.



as many "throws" as pistons.
May be in same or different
planes. The eccentricity is the
throw.

Piston fastened to throw by ~~rod~~ rod.

Bearings. Those in middle are journal bearings. Shaft forged
from solid piece of nickel steel. Counterweights to balance
throw.



Shell has to be double because oil of
very high viscosity is used, &

when bearing burns out, it can be
replaced.

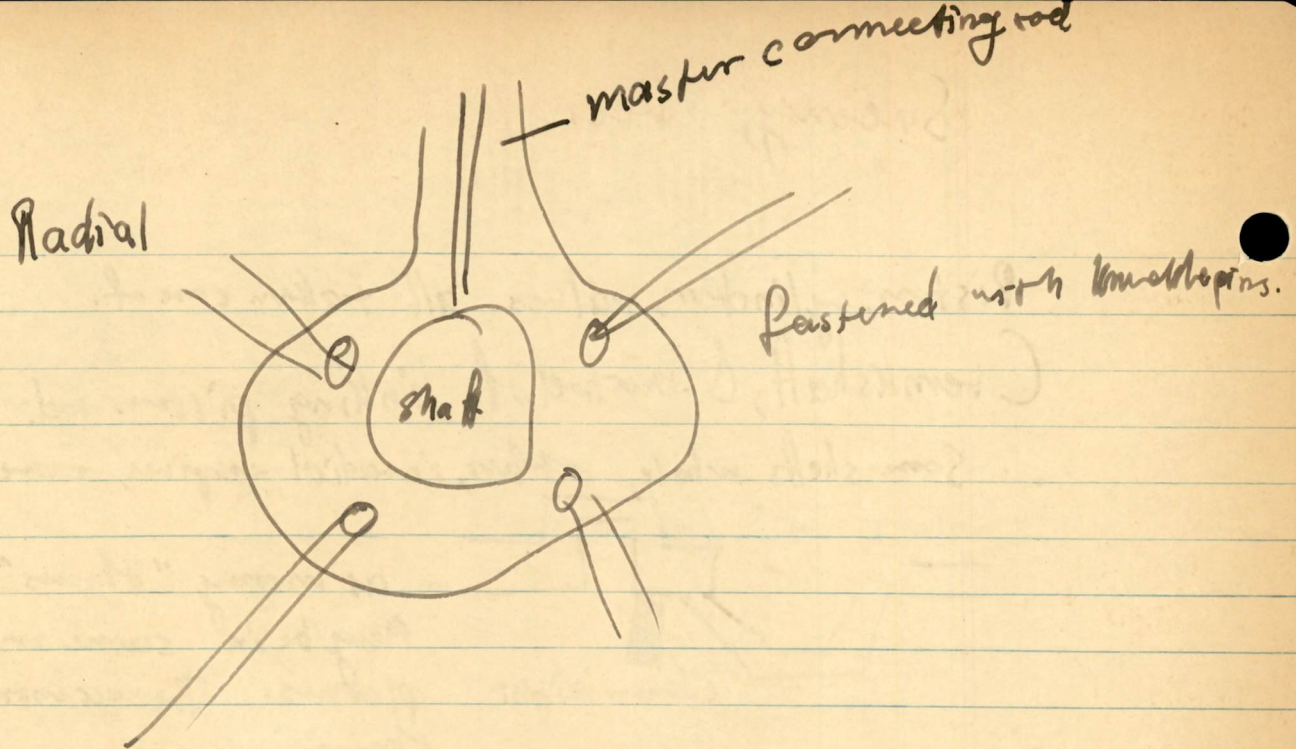
Bronze lined with Babbitt between shell & shaft. Melts
when hot, gives shaft play. Babbitt is the bearing.

On the ends of shaft, ball bearings instead. Rubbing
Babbitt vs. steel generates little heat, makes an anti-friction
combination, with lubrication. Babbitt wears away fast.

28% efficiency of most gas motors.

Other method of reducing friction - reduce surfaces in
contact, with ball bearings. Or roller bearings - ball more
common.

In radial engine, the case is one piece. Throw will come
apart at outside ~~the~~ ^{the} inner piece at outside is grooved
& are keyed together, a spline shaft.



Reason for splines is so shaft can come apart to receive all pistons.

How determine hp of engine? $Work = force \times distance$
 If you push a wall, $work = 0$, as distance is 0.

Unit of work is the foot pound - moving one lb. 1 ft.

$$Power = \frac{Work \times time}{time} \quad \text{Rate says}$$

$$Horsepower = \frac{33,000 \text{ ft. lbs per minute}}{550 \text{ " " " sec.}}$$

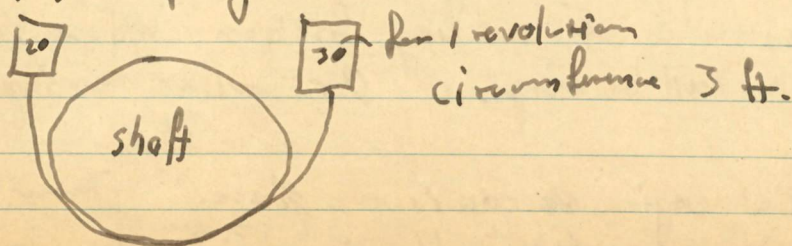
$$746 \text{ watts of elect. (per what?)}$$

$$Power = \frac{Work \times time}{33000 \times \text{no. of min.}}$$

$$HP = \frac{\text{foot lbs}}{33000}$$

Prony Brake - device to measure hp.
 shaft, 2 spring balances

Belt around



$$\begin{array}{r} 30 \\ -20 \\ \hline 10 \\ \times 3 \\ \hline 30 \times 2000 \text{ RPM} \\ \hline 60,000. \end{array}$$