1605203
SGT GOULD A.G.
2 WORKSHOP
CLASS 3

Form 619.

ROYAL AIR FORCE.

S Corby

School.

Notebook for use in Schools.

91/3471. Wt. 3390 900M. Bks. 8/42. J.D. & Co. Ltd.

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2 V Cell 6 V Cell GENERATOR MOTOR SWITCH

FUSE & LAMP EARTH OR ADMEETER

VOLTMETER REGISTANCE SOLENOID

SOLENOID RELAY CONDENSER OR

V PARALLEL SERIES

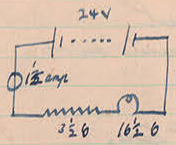
Electrics.

For a current to flow in a circuit it is necessary to have (1) An electrical pressure or E.M.F.
(2) Conductive Material.
(3) Complete Circuit.

E.M.F. is measured in Volts with a Volt Meter connected in Parallel with the circuit.
Current is measured in Amps by means of an Ammeter which is connected in Series with the circuit.
Resistance is measured in Ohms and depends upon length & gauge of wire.

Ohms Law.

Volts ÷ Current = Resistance in Ohms.
Volts = Current × Resistance.
Volts ÷ Resistance = Current.



Longe resistance of Lamp so that amps are $2\frac{2}{6}$ amps = $6\frac{1}{2}$ ohms.

Power - measured in Watts
1 Watt = Volt × Amps

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746 Watts = 1 Horse Power

Connection in Series.

(1.) Bells — 2V 2V 2V = 6V

(2) Resistance — 2Ω 2Ω 2Ω = 6 Ohms

Connection in Parallel.

(1.) Bells — 2 2 2 = 2V

(2) Resistance — 2 2 2

$\frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{10} = \frac{10+5+2}{20}$

$= \frac{1}{R} = \frac{17}{20}$ $R = \frac{20}{17} = 1\frac{3}{20}$ x

Magnetic Effect of a Current

Strength of a field depends on:—

(1.) Current.

(2.) No of turns.

i.e. on the number of turns,

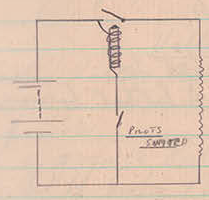
(3.) Whether coil is wound on soft iron.

Point to be considered in wiring an aircraft.

(1) Voltages required to operate the various components.

(2.) Size of cables - weight involved.

(3.) Size of switches - space involved.



Relay Switch

Accumulators.

Lead Accumulator.

Voltage per cell 2·2

2 Plates 1 of Lead Peroxide Composition Positive

1 of Lead. Negative

Diluted Sulphuric acid.

Fully Charged Condition

Specific Gravity 1·35

Voltage 2·2 V.

Final Charge while Gassing 2·7 V

Fully Discharged Condition.

Specific Gravity 1·18.

Voltage 1·8

Discharge weakens acid & forms lead Sulphate on plates.

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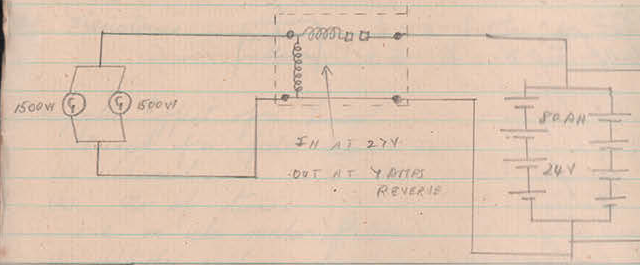
Amp hour Efficiency must be 60% to be airworthy.

Capacity: Measured in amp hours based on the 10hr Rate.

Efficiency is the Amp hour discharge / amp hr charge. approx 80-90%

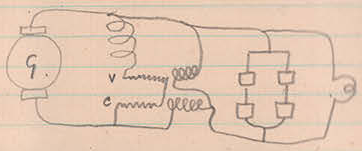
Generator bats out. 27V to cut in
7 amps to cut out (reverse current)



Relay Switch. (1) Handles the heavy current
(2) Wiring run is shortened (3) Volts drop in run is lowered. (4) Heavy cabling kept from cockpit.
Used
Landing Lamps, Undercart, or Motion.

Voltage Regulation

2 Parts Voltage Reg & Current Regulation
Generators are connected in Parallel.
Shunt Generator.
Speed & Magnetic Field Control the current of the generator
Controlled by Carbon Pile.
Magnet works motor which opens Carbon Pile
↘ worked by coil connected across brushes of Generator.
Dashpot prevents the motor from jackbinding



2 Voltmeter in charging circuit but no Ampmeter

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Theory of Flight

Air Resistance (Drag), depends on:—

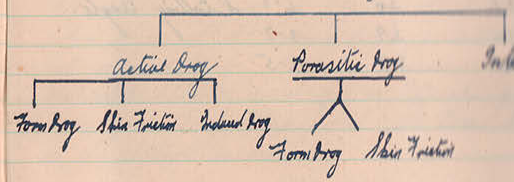
(1.) Shape & attitude
(2.) Frontal Area
(3.) Air Density (·077 lb ⊞ ft at sea level)
(4.) $(\text{Airspeed})^2$

Types of Drag.

(1.) Form Drag – due to shape, reduced by streamlining
(2.) Skin Friction – reduced by polishing, etc.
Fineness Ratio = Length ÷ Max Width which should be 5 to 6.
Skin Friction – due to nature of surface & air viscosity.
(3.) Induced drag – due to production of Ax – reduced by using high aspect ratios, tapering, etc.

Total Drag.

- Active Drag
  - Form Drag
  - Skin Friction
  - Induced Drag
- Parasitic Drag
  - Form Drag
  - Skin Friction
- Interference Drag.



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Aerofoil.

Bernoulli's Theory.

Total energy of a fluid = Constant

Kinetic Energy + Pressure Energy = Constant

Thus an increase in speed will cause a decrease in pressure & vice versa (Venturi Effect)

Production of Lift.

Angle of attack	L	D	L/D	
-4	18	8	2·3	
0	54	9	6	
2	74	10	7·4	Optimum angle.
4	88	12	7·3	
6	98	15	6·5	
8	112	18	6·2	
10	122	20	6·1	Stalling angle.
12	106	29	3·7	
16.	46	39	2·5	

Indicated Air Speed (I.A.S) = Speed given on A.S.I.

Rectified Air Speed (R.A.S) = IAS ± Instrument Error Correction ± Position Error Correction.

True Air Speed = R.A.S × altitude Correction Factor

Position Error Correction at 65,000 ft Speed with Pressure Head on Top of Fuselage.

FROM	115	120	130	140	150	160	175	190	205	I.A.S.
TO	119	129	139	149	159	174	187	204	220	R.A.S.
SUBTRACT	8	6	4	2	-0					
ADD						2	4	6	8	

I.A.S = 199

Instrument Error +1 · Position Error = +6

RAS = 206 TAS 206 × 1·3 = 267·8 mph.

174 + 2 + 4 = 180 1·42 = 255·6

The total drag of an aeroplane in level flight is least when flying at the Optimum Angle of attack and the speed at this angle of attack is known as the Economical Cruising Speed. Indicated Stalling Speed for an A/C of given weight is the same for all altitudes, but the True Stalling Speed increases as the altitude increases.

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(S.H.F.) Steady Horizontal Flight

Relationship between airspeed & angle of attack

Economical Cruising Speed.

S.H.F. is Flight at Constant Height at a Constant Speed.

For an aircraft to be in S.H.F. the two following conditions must be satisfied:-

Lift = Weight of aircraft

Thrust = Drag

An aircraft may be in steady H.F. at different angles of attack and different air speeds.

For a given age at a given weight, for each angle of attack there is one corresponding speed of horizontal Flight & / only.

Assume a Stirling weighing 65,000 lbs is in S.H.F. at 6° Angle of attack & 165 miles an hour. Then the same aircraft could be flown at a greater speed but the angle of attack would have to be less than 6°. Similarly it could be flown at a less speed but in this case the angle of attack would have to be more than 6°.

However, out of all these possible combinations of angle of attack & airspeed, only / angle of attack & thus only / corresponding airspeed will at the same time give minimum drag & hence maximum range.

The angle of attack is the optimum angle and the corresponding airspeed is Economical Cruising Speed.

The effect of Weight of aircraft on Cruising Speeds.

Example

Stirling.

6 aircraft bound. (Theory)

Recommended I.A.S = 165 m.p.h.

Homeward bound (Light)

Recommended I.A.S. = 160 m.p.h.

The reason for the above difference is the difference in weight carried on the two trips.

No matter what the weight of the same aircraft, for maximum range it must be flown at the 6 optimum angle of attack.

Thus the less the weight of the aircraft, the less Lift required, hence the less speed required to give the lift.

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Engineering Science.

Graphs of Hercules Economical Cruising Boost & Rem & Altitude Correction Factor.

For any particular power requirement with in the economical cruising range the best condition are obtained by reducing the R.P.M. and keeping the boost upon long as it does not exceed +1 lb

Engine Operational Conditions			B.P.
Takeoff (3 mins)	RPM	28,000	+6 3/4
Max Climb (30 mins)	"	25,000	+3 1/2
Max for continuous cruising (Rich)		25,000	+3 1/2
Max Cruising (Weak)		25,000	+1
Max All Out Level (5 min)		28,000	+6 3/4

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Supercharging.

Volumetric Efficiency = $\frac{\text{Weight of charge forced in per Molecular Stroke}}{\text{Weight of charge to Fill Swept Vol at N.T.P.}}$

Normal Temp = 15° C.
Normal Pressure = 14·7 lb □"

High Boost, Low Res for Maximum Range

Methods of increasing power

$$I.H.P = \frac{PLANC}{2 \times 33000}$$

I.H.P. may be increased by

(1.) Increasing C (Cylinders) Limits, cooling, weight, drag.

(2) L.A. (Stroke + Area = Swept Volume limits as before

(3) Increase N (RPM It takes more power to drive Auxiliaries, rubbing loss, centrifugal forces & Inertia increase. Dynamic Stress. Gas speed.

(4) Increase Pressure. In this case the increase in power would be got without the losses involved in (3), thus it is best to Increase Pressure. To do this we apply a Supercharger, rather than using light

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compression ratio.

Boost Pressure (British Engines)

Pressure above + or below − (14.7 lb □"). Note the Ministry on Boost + RPM for specified operational condition (See Handbook)

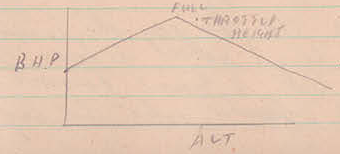
Climb

(1.) Atmospheric Pressure Decreases, Power falls off
(2.) Temp decreases, This will tend to compensate for fall off in power to (1)

Combined effect of 1 + 2 gives us a fall in Power

Power altitude curve N.A. Engine

Effect of Maintaining constant Induction Pressure with S/C + ABC.



The gain to full throttle Height is due (1) To boosting
(2) Better Scavenging, both at altitude.

Pressure Ratio of S/C = $\frac{\text{Outlet Pressure}}{\text{Inlet Pressure}}$

Comparison of M + S Gear

	Boost	Charge Temp	Gross BHP	BHP to drive SC	Power Available
S	+3	74° C.	1085	72	1013
M	+3	19° C	1180	30	1150

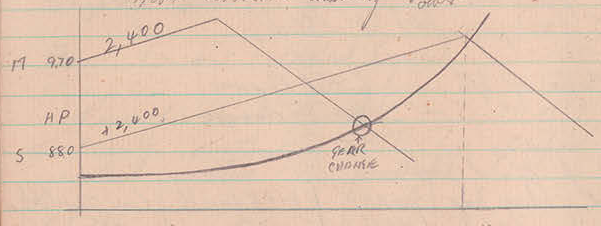
Cooler because compression is less due to lower Temp

Better VE

(a) High Revs - Low Boost
(b) Low Revs - High Boost
(c) Both Revs + Boost Lower.

(a) Charger absorbs power without much benefit, Engine + auxiliary losses high. (More Oil)
(b) Power taken by Charger reduced, Engine losses reduced

Max Available Cruising Power



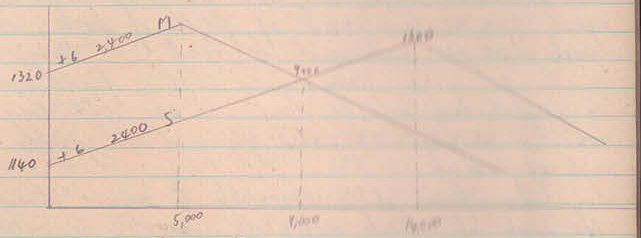
to fly @ 170 I.A.S

The power required to fly an aircraft at any given I.A.S. increases steadily with altitude as shown by the graph. The increase is due to the increase in T.A.S while the drag remains constant.

The altitude where the power required crosses the power available is the ceiling of the aircraft. This ceiling is not fixed because as the speed & load vary, the power required line varies if S gear is engaged at sea level the power available drops because of the higher temp of the S gear charge & the extra power to drive S gear, but due to the higher gear ratio the boost pressure can be maintained to a higher altitude.

S gear always requires more fuel per H.P. than M therefore whenever possible M gear must be used. When cruising engage S gear only if the speed required cannot be obtained in M.

Climbing



Gear change when climbing.

The gear to use in a climb is always the one which is capable of giving the higher rate of climb. That is the one which gives the greater horsepower. From sealevel up to 9,000 ft M gear gives more H.P. than S despite the fact that at 9,000 ft the boost in M has dropped to +3½. From 9000 ft on S gear gives more H.P. than M. Therefore when climbing change to S gear at 9,000 ft or where the boost in M has dropped to +3½.

Performance.

Range Flying - Big bomb load - smallest possible fuel load.

Range Flying.

This is the condition of flight normally met in a Stirling, where the pilot is trying to obtain maximum miles per gallon. For this the pilot used per mile

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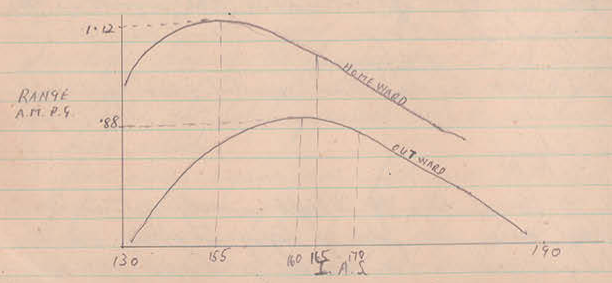
must be least, and since each gallon of petrol is equal to a certain number of ft lbs of work, the work done per mile must be least i.e. Drag must be a minimum. Since lift is speed equal to weight, drag will be least when the lift drag ratio is greatest i.e when flying at the optimum angle of attack.

In flight it is impossible to measure directly the angle of attack sufficiently accurately to make sure of flying at the optimum angle. At the average all-world load of 66,000 lbs the optimum angle can only be obtained by flying at 160 I.A.S. and on the return journey when the load is reduced to 55,000 average, the speed must be reduced to 155 I.A.S to maintain the optimum angle. Therefore the speed given above as the most economical one will give Maximum A.M.P.G.



Gilwood

I.A.S.	Range
140	·815
150	·86
160	·875
170	·87
180	·84
190	·77

Horwood

I.A.S.	Range
140	1·05
150	1·11
160	1·12
170	1·10
180	1·04
190	·92

(1) $\frac{220}{460} \times \frac{4}{8}$ 1280 + 300 = 1580

(2) $\frac{400}{1200} \times \frac{4}{12}$ 1600 + 300 = 1900

(3) $\frac{221\frac{1}{3}}{664} \times \frac{4}{8}$ $885\frac{1}{3}$ + 300 = 1184

(4) $\frac{331\frac{1}{3}}{1016} \times \frac{4}{8}$ $1354\frac{2}{3}$ + 300 = 1655

Loadings

(1)	(2)	(3)	(4)	(5)	(1)	
2	2 or 2	2	2	2	2	80
4	4 4	4	4	4	4	221
5	5 5	5	5	5	5	63
	6 1	6	6	6	6	284
1498	1660/58	1	1	1	1	164
		1820	3	7	3	172
			1946	2128	7	1184
					2354	

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59552
9280
68832

Trip 1200 Fuel required 1900. Fuel Taken 1946

Weight of fuel 1946
7·2
136220
3892
14,011·2

2913
874 4
3

1165 1/3 + 300
1465 1/3
1466

Fuel 1466 Taking 1660

Tare	43,200
Service	4,400
Fuel	14,012
A/C Less Bomb	61,612
T/O Weight	69,000
Max Bomb	7,388

Weight of Fuel 1660
7·2
116200
3320
11,9520

360
8
2880

Tare	43,200		
Service	4,400		
Fuel	11,952	Bomb	6,000
A/C Less Bomb	59,552	Incendy	2880
T/O	69,000	Cannon	400
Max Bomb	9,448		9,280
Bomb Carried	9280		

Total T/O Weight 59,552 + 9,280
= 68,832 lb.

With the exception given below the range obtainable in a Stirling is independent of the altitude at which the aircraft is flying. The reason is that as altitude increases the pilot must maintain the same IAS to get maximum range and is therefore encountering the same drag.

Therefore the work done per mile is the same at all altitude, and the range obtainable does not alter.

Exceptions.

At some altitude the engine can get work out of petrol with greater efficiency than at others and therefore at the more efficient altitudes the range obtainable will increase. Above about 16,000 ft 5 gear must be engaged and below about 6,000 ft the engine is partly throttled, therefore at these particular altitude engine efficiency drops and range is reduced.

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TIME	HEIGHT	ATT	RPM	BOOST	MIX	GEAR	CALC. RDNG.	FUEL USED	
23.57	—	T.O	2800	$8\frac{1}{4}$	R	M	—		
00.00	1,000	C	2400	6	R	M	—	50	TO + RU = 50 gals
00.10	6,000	L	2100	2	W	M	56	84	$8.4 \times 10 = 84$
00.55	6,000	C	2400	6	R	M	—	168	56×45 mins $= 42 \times 4$ 168
01.15	13,000	L	2200	2	W	S.	58	168	$8.4 \times 20 \times \frac{4}{3} = 224$
02.50	13,000	C	2400	6	R	S	—	387	$58 \times 4 \times 1\frac{2}{3} = 387$
02.55	14,000	L	2400	2	R	S	62	42	$8.4 \times 5 \times \frac{2}{3} = 42$
03.20	14,000	C	2400	6	R	S	—	140	$62 \times 4 \times \frac{25}{60} \times \frac{4}{3} = 140$
03.25	16,000	L	2300	2	W	S	62	42	$8.4 \times 5 = 42$
03.55	16,000	D	2100	0	W	M	53	124	$62 \times 4 \times \frac{30}{60} = 124$
04.00	12,000	L	2200	2	W	M	61	18	$53 \times 4 \times \frac{5}{60} = 18$
05.00	12,000	D	2000	$-\frac{1}{2}$	W	M	46	244	$61 \times 4 = 244$
05.10	4,000	L	2100	$1\frac{1}{2}$	W	M	53	31	$46 \times 4 \times \frac{10}{60} = 31$
06.25	4,000	D	2300	-1	R	M	48	265	$53 \times 4 \times 1\frac{1}{4} = 265$
06.30	—							22	$48 \times 4 \times \frac{5}{60} \times \frac{4}{3} = 22$

Duration Cruising (Endurance)

This condition is not very common with a Stirling. It occurs when the pilot is trying to obtain Max Time in the air. The time in the air depends on the G.P.H. & will be greatest when the G.P.H. is least i.e. when the H.P. is least. To reduce the H.P. Pilot must operate his revs & throttle, and as he cuts the H.P. the speed will drop and the angle of attack will increase.

As this happens the amount of control over the case becomes smaller. Minimum galls per hour are obtained when the H.P. has been reduced just sufficiently to allow the pilot, reasonable control.

Range flying is minimum power.
Duration flying is minimum work.

For minimum control the pilot must maintain a certain I.A.S. and the power required to do this will increase steadily as altitude increases owing to the increase in T.A.S. Therefore gallons per hour will be least and duration greatest when flying at the lowest possible operational altitude.

Calculation

(1) Enter Fuel Left.
(2) Switch Tanks
(3) Subtract Fuel

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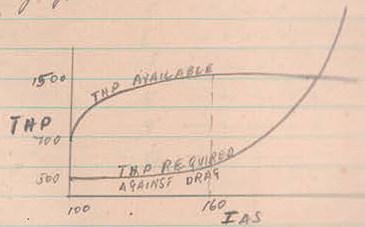
TIME	HT	ATT	RPM	BOOST	MIX	GEAR	RATE RONS	FUEL USED
22.57	TO	C	2800	8¼	R	M	—	
23.00	1,000	C	2400	6	R	M	—	50 8·4×15 = 126
23.15	8,000	L	1850	½	W	M	46	126 46×4×30/60 = 92
23.45	8,000	C	2400	6	R	M	—	92 8·4×15 = 126
00.00	15,000	L	2100	0	W	S	50	126 50×4×30/60 = 100
00.30	15,000	L	2400	2	R	S	63	100 63×4×15/30×4/3 = 84
00.45	15,000	L	2100	0	W	S	50	84 50×4×25/60 = 117
01.20	15,000	D	1850	½	W	M	47	117 47×4×5/10 = 49
01.35	5,000	L	1850	−1	W	M	40	47 40×4 = 160
02.35	5,000	D	2300	−2	R	M	44	160 44×4×1/12×4/3 = 20
02.40	—	—	—	—	—	—	—	20 15
								923

(a) GPH = Fuel / Time g/h = g/0

AMF TAS/180 / GPH m/s = m/s / g/h

Climbing

During a climb the engines are working against 2 forces – Drag + Gravity & the rate of climb will depend on the amount of H.P. which can be used against Gravity. The H.P. used against Drag increases steadily as forward speed increases but the Thrust H.P. available from the engines in a climb also increases as forward speed increases due to a steady rise in propeller efficiency. These 2 facts are shown by the 2 graphs – T H P available & H.P. against Drag.



From the graph it will be seen that the biggest margin of power available for climbing lies at about 160 I A S therefore this speed will give the highest rate of climb. To obtain this speed the engines are opened up to Max Climbing (2400 R 16) & the speed reduced to 160 by adjusting the angle of climb.

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A ·—
B —···
C —·—·
D —··
E ·
F ··—·
G ——·
H ····
I ··
J ·———
K —·—
L ·—··
M ——
N —·
O ———
P ·——·
Q ——·—
R ·—·
S ···
T —
U ··—
V ···—
W ·——
X —··—
Y —·——
Z ——··

Commence ···—·· VE
End ·—·—· RN
Long Break —···— DA
Plain Language ··—·—·— AAA
Erase ·········· 8 I's

1 ·————
2 ··———
3 ···——
4 ····—
5 ·····
6 —····
7 ——···
8 ———··
9 ————·
0 —————

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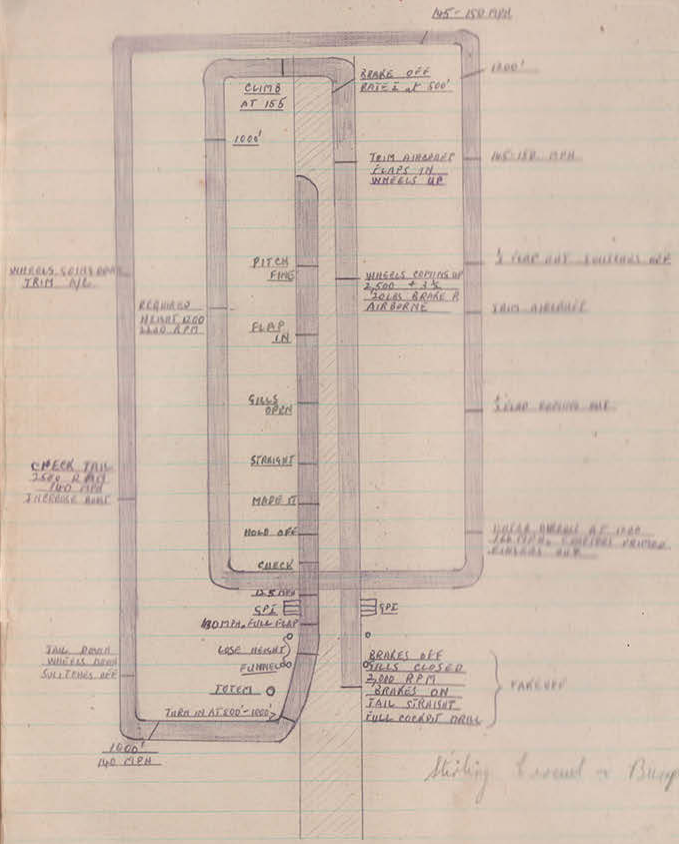

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TIME	HEIGHT	ATT	RPM	BOOST	MIX	GEAR	CALC	FUEL	
10.57	I.O.	L	2900	$8\frac{1}{4}$	R	M	/		
11.00	1,000	C	2400	6	R	M	/	50	
11.15	7,000	L	1850	$\frac{1}{2}$	W	M	46	126	$8.4 \times 15 = 126$
12.15	7,000	C	2400	6	R	M	/	184	$46 \times 4 = 184$
12.30	14,000	L	2050	0	R	S	49	126	$8.4 \times 15 = 126$
13.00	14,000	D	1900	$\frac{1}{2}$	W	M	49	131	$49 \times 4 \times \frac{30}{60} \times \frac{4}{3} = \frac{45}{3} \times 4 = 130\frac{2}{3}$
13.15	6,000	L	1850	$\frac{1}{2}$	W	M	45	49	$49 \times 4 \times \frac{15}{60} = 49$
14.00	6,000	D	1850	$-\frac{1}{2}$	W	M	42	135	$45 \times 4 \times \frac{5}{4} = 135$
14.05	4,000	L	1850	-1	W	M	40	14	$42 \times 4 \times \frac{5}{60} = 14$
15.50	4,000	D	2200	$1\frac{1}{2}$	R	M	55	280	$40 \times 4 \times \frac{105}{60} \times \frac{4}{3} = 280$
15.55	—	—	—	—	—	—	/	25	$55 \times 4 \times \frac{5}{60} \times \frac{4}{3}$
								1120	

1100
278.70

60 min 51 gal.

30 min 32 = 16
20 min 43 = $\frac{43}{1} \times \frac{20}{60}$ = 15
10 min 52 = $\frac{52}{6}$ = 11
162

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