5. Repeat when rig has completed nine revolutions.

## Analysis

The first calculation determines when, during the run, the propeller has the required forward velocity VR. For a rotation rate w (revs/sec) and rig radius c,

prop velocity $V = 2wc$

Let $T5$ = time for first five revolutions of rig (secs.)

$T10$ = time for 10 revolutions of rig (secs.)

The average propeller forward velocity for the first five revolutions (to a close approximation, the value at 2.5 revolutions) is

$$V1 = 10c/T5 \qquad [1]$$

Similarly, the value at 7.5 rig revolutions (average of second five) is

$$V2 = 10c/[T10 - T5] \qquad [2]$$

Assuming V varies linearly with N,

Number of rig turns completed when $V = VR$ is

$$NR = (5*(VR - V1)/(V2 - V1)) + 2.5 \qquad [3]$$

To evaluate the number of turns unwound when $V = VR$, it has been found accurate enough to assume that the prop rpm remains constant.

Given that

$nS$ = number of turns on motor at start

$nL$ = number of turns on motor at end of run

Number of turns used when $V = VR$

$$nR = (nS - nL)*NR/10 \qquad [4]$$

Average prop rpm $\underline{R} = (nS - nL) * 60/T10$, which will, to a close approximation, be the value at five rig revolutions, ie $\underline{R} = R5$

It will be noted that the prop rpm has been measured at 1, 5 and 9 revolutions of the rig, to give R1, R5 and R9; this is done to calculate the correction factor k for the prop rpm.

It is not as easy to obtain an accurate figure for the prop rpm and keep count of the rig turns completed at the same time as to concentrate on just measuring the prop rpm! Therein lies the reason for measuring at 1, 5 and 9 revolutions; this increases the accuracy of the linear fit with respect to the rig turns.

Calculate

$$x = (R1 - R9)/2*R5$$

then the prop rpm factor for NR rig revolutions completed is

$$k = 1 + x - (NR - 1)x/4 = 1 + (5 - NR)x/4 \qquad [5]$$

and actual prop rpm at NR revolutions is

$$r = k\underline{R} \qquad [6]$$

Given that $T50$ = motor torque at 50 turns unwound

$T100$ = motor turns at 100 turns unwound

then by linear interpolation

$$TR = ((nR - 50)(T100 - T\,50)/50) + T50 \qquad [7]$$

is the motor torque at the required point.

The power consumed by the propeller at velocity VR is thus

$$P = R*TR$$

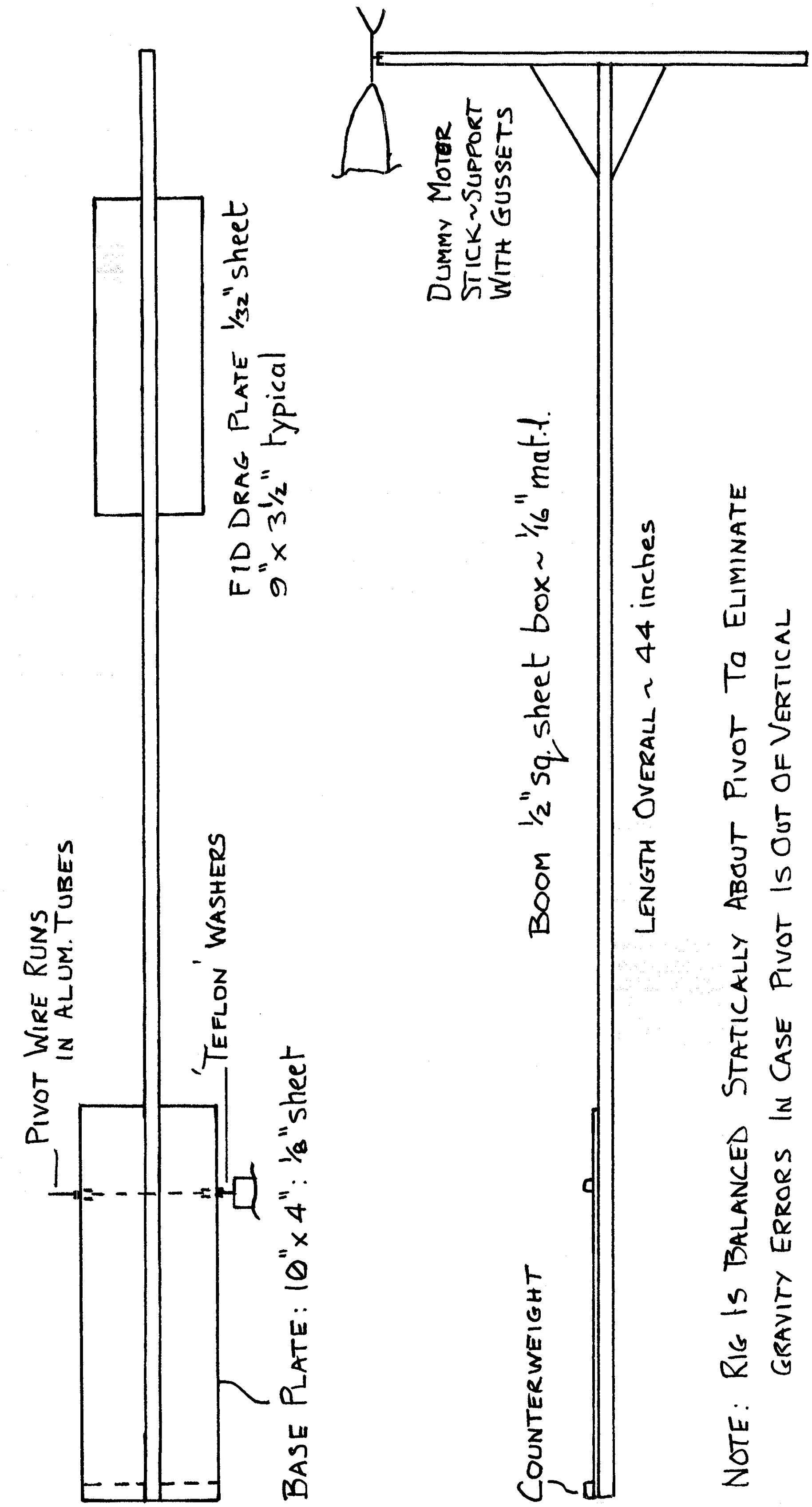
## Typical results

My tests have shown the following general features.

1. It is essential to keep one propeller (often the best known from flight testing) as a reference when conducting tests on other, relatively unknown propellers. Conditions can vary quite markedly from one day to the next, depending on, for example, time of day and whether the heating is on or not.

2. Repeat measurements for the same propeller to check consistency give indicated power consumption values to within 2 or 3%; rig rotation times are virtually consistent to 0.2 to 0.3 seconds.

3. Results have given a good qualitative assessment of the differences between individual props. In particular, the effect of a pitch change is readily observable in terms of the effect on torque and on rpm. A 1 degree change in




*Details of the test arm used for propeller development work.*

blade angle gives an observable change in torque and rpm.

4. Results have indicated that higher torque values of T5 do not auger well for the propeller performance (ie. less thrust at higher torque) despite giving good predicted cruise torque performance. This seems to apply to the higher pitch propellers.

## Conclusions

1. The rig provides a useful guide for assessing one propeller relative to another. It does not necessarily promise optimum duration for the model in flight; no attempt has, as yet, been made to assess climb performance on high torque.

It is necessary to note that the rig does not simulate the performance of the prop when the model is descending because the model is being pulled forward by its own weight in addition to the propeller thrust. This is not the case on the rig.

2. Although not yet investigated, the rig deceleration (10 - T5 compared with T5) may give a clue to the prop performance in other regimes of the model flight. More comparisons with model performance data are required to assess this possibility.