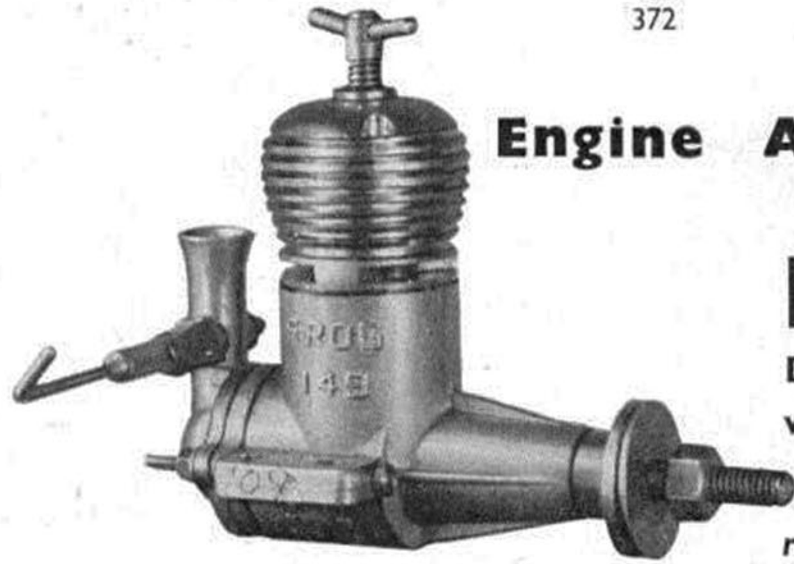


Engine Analysis No. 23

FROG 149's

DIESEL and GLOWPLUG with "Vibra-matic" induction

reviewed by R. H. WARRING

INTERNATIONAL MODEL AIRCRAFT are certainly right back in the engine market with a whole spate of revised and new engines. Latest of these is the "149" which, whilst retaining many of the features of the "150", has diaphragm-controlled induction direct into the crankcase, the diaphragm being a 11/16 in. diameter disc of .005 in. pen steel, loaded by means of a coil spring. This type of valve is essentially similar in action to the now familiar reed valve, but a much simpler production job and also virtually immune from fatigue since the valve disc is a separate, integral unit and the spring itself is only lightly stressed.

Details of the valve are shown in the exploded drawing. The back cover of the crankcase is in the form of a shallow cylinder extending into the crankcase proper with generous area ports cut in top and bottom. Onto this butts the choke tube assembly—a rather odd shaped unit which has been likened in appearance to the front end of an "Emmett" railway engine—and between the two is the diaphragm, spring loaded by a coil spring to rest normally against the face of the induction chamber.

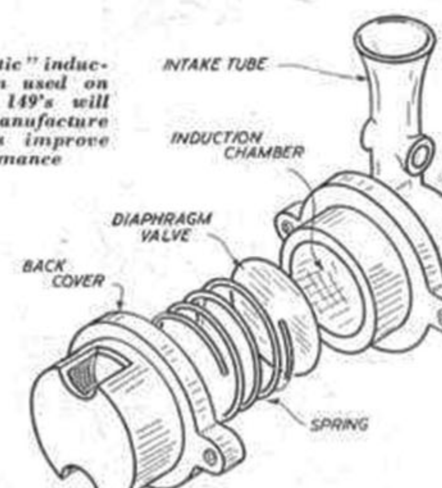
Suction pressure within the crankcase at the appropriate part of the cycle draws the diaphragm inwards, away from the induction chamber facing and against the action of the spring, remaining open all the time there is sufficient suction and thus allowing the mixture to be drawn into the crankcase in the normal way. As soon as the suction pressure falls off the spring takes over to close the valve for the remainder of the cycle. Thus direct induction to the crankcase, controlled by suction pressure and thus self- or automatically timed, is achieved independent of the other working parts of the engine—reed valve induction with a much more robust unit.

In practice, and particularly at high speeds, almost certainly the diaphragm "floats" as the inertia of the system would preclude its completely opening and closing at such frequencies. The extent of "float" or true cycling would, of course, depend on the spring tension and this is quite surprisingly high. The extent to which the valve remains "open" whilst there is positive pressure (compression) within the crankcase cannot be high, however as the predominant pressure is positive over a whole cycle and were the induction system "open", fuel would be blown back out of the choke tube. This does, in fact, occur on the Frog "149" if a much weaker spring is used when a whole plume of fuel spray rises out of the top of the choke tube, but with the engine still continuing to run. Thus spring tension is far from critical. The blow-back which does occur could, indeed, have a beneficial effect in turbulating the mixture and promoting better atomisation. Suffice it to say that this simplification of reed valve induction works and works extremely well, although we understand that it is not directly applicable to any engine. With smaller capacities, for example, it has so far given very indifferent results.

Probably because of the method of induction, the "149" has some unusual characteristics. On the basis of straight power performance it is somewhat superior to its conventional counterpart, the Frog "150". Since these two motors use the same crankshaft, cylinder, piston, con. rod, etc., this difference must be attributed to the induction. Rather more striking, however, is the extreme speed range possible with the "149" and the peculiar "delayed response" one gets on leaning out the mixture too much. Nothing happens for several seconds on over-closing the needle valve and by the time one realises that the engine is starving it will have stopped by the time the re-adjustment had taken effect. Once having tumbled to the time lag between "cause and effect", the answer in such cases is to momentarily choke the intake with a finger to keep the engine running until it picks up on its own. Needle valve adjustment is, in any case, quite coarse and it is probably far easier to run on a slightly rich mixture. Mixture adjustment at the lower end of the speed range can almost be ignored, provided it is rich enough, but fine adjustment gives that little extra at the top end and does result in an appreciable saving in fuel, which could be important on a team racer if ever used for this purpose.

The speed range is of the order of 5 : 1—even higher if you take into account that the ultimate free-running

"Vibra-matic" induction system used on these new 149's will simplify manufacture as well as improve performance



speed is well in excess of 20,000 r.p.m. But by speed range we really mean the range of speeds given by extremes of propeller sizes on which the engine will run normally and consistently. Down at the lower end, for instance, the "149" swung a 11 x 6 high-thrust propeller smoothly and consistently at 3,600 r.p.m. without a miss or falter and the torque at this end was almost constant at 12.5 ounce-inches up to roughly double this speed. At the upper end of the scale it would start just as readily—although you had to mind your fingers here—and scream a 6 x 4 nylon prop around at a consistent 16,000.

A 10 x 4 or a 9 x 5 or 8 x 6 might, in fact, be an excellent. prop size for sports or radio flying. The engine peaked at 12,750 and so any propeller size giving more than about 11,000 r.p.m. on the ground would be wasting power in the air, which looks like an 8 x 4 or a 9 x 3 as the best size for free flight and a 7 x 6 for control line. The "149" would appear readily capable of handling higher pitch propellers for control line work, provided the blades were trimmed to keep up the revs.

We also investigated the "two-speed" properties of the "149" on account of its obvious attractions for radio control work. Twin needle valves are one solution, one adjusted for normal and the other for very rich mixture but closing the intake tube with a clapper drilled with a $\frac{1}{32}$ in. hole produced the most satisfactory results. Removing the choke too rapidly, however, would sometimes cause the engine to stop entirely instead of picking up on the weaker mixture. This however, would appear to be largely a matter of further experiment to decide on the best form of choke and linkage. The needle valve, incidentally, is locked by a weak spring ratchet which is quite positive in action and, being behind the cylinder, this control is readily accessible.

The cylinder unit, as mentioned, is identical with that of the Mark II "150" and so needs no further description. The crankshaft is essentially the same, except that it is not drilled (and therefore slightly heavier) and also the web has been thickened up slightly and the crank pin made a little longer. Although the same overall length, the propeller backplate is narrower and so there is a longer length of shaft protruding, sufficient to accomodate the highest pitch propellers likely to be employed and also screw-on spinners. The propeller nut thread is 2 B.A. The propeller backplate is broached to fit over a splined section of the crankshaft, rather than a friction fit on a taper.

DIESEL

PROPELLER—R.P.M. FIGURES

Propeller dia. x pitch	r.p.m.
11 x 6 (Super Scru)	3,600
10 x 6 (Frog nylon)	6,100
9 x 6 (Frog nylon)	8,100
8 x 6 (Frog nylon)	8,000
9 x 4 (Stant)	8,200
8 x 5 (Frog nylon)	9,000
7 x 4 (Stant)	11,500
8 x 4 (Stant)	10,750
6 x 5 (Stant)	13,500
6 x 4 (Stant)	13,900
6 x 3 (Stant)	14,500
6 x 4 (Frog nylon)	16,200
7 x 6 (Stant)	10,800

Fuel : Frog "Powamix".

The crankshaft bearing will, perhaps, be something of an eye-opener for those of the "gen boys" who like to judge an engine by the amount of, or rather lack of, side play on the shaft. The main bearing has a generous clearance of the order of 1 to $1\frac{1}{2}$ thou., this being quite deliberate and, in fact, recommended by the makers of the Vandervell bearing used as the optimum fit for the speeds and loads concerned. The bearing itself is of sintered bronze, steel backed and is only reamed to finish, once fitted. It is obviously perfectly satisfactory in service as neither the shaft or bearing showed signs of localised overheating or wear after extended running a lot of which was at 12,000 r.p.m. plus, and remained cool throughout. Yet handling the new engine one can readily wobble the shaft in its bearing and when running it dribbles an appreciable amount of oil out of the front end. It would seem worthwhile to repeat that this is not a "fault", but a "characteristic" and the loose bearing fit has probably quite a lot to do with the excellent power performance achieved at the top end of the speed range.

Employing a similar crankcase casting to the "150", the "149" is primarily intended for beam mounting, although the fact that the backplate and induction assembly are held in place with two 8 B.A. screws

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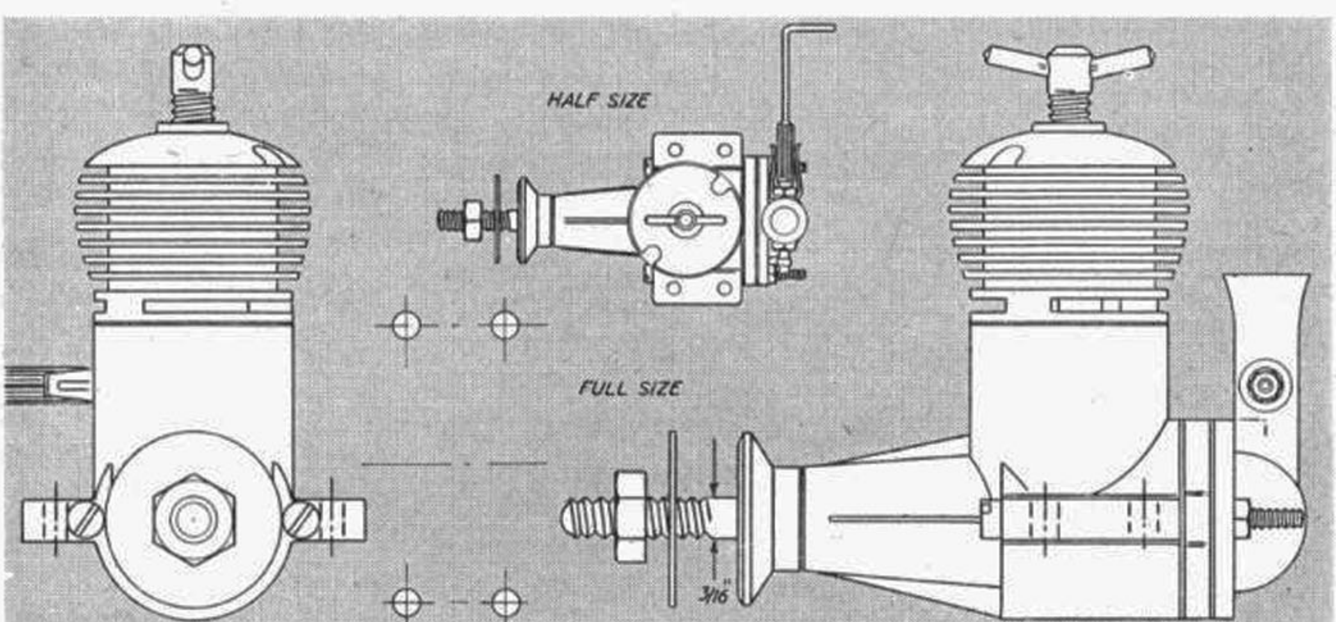

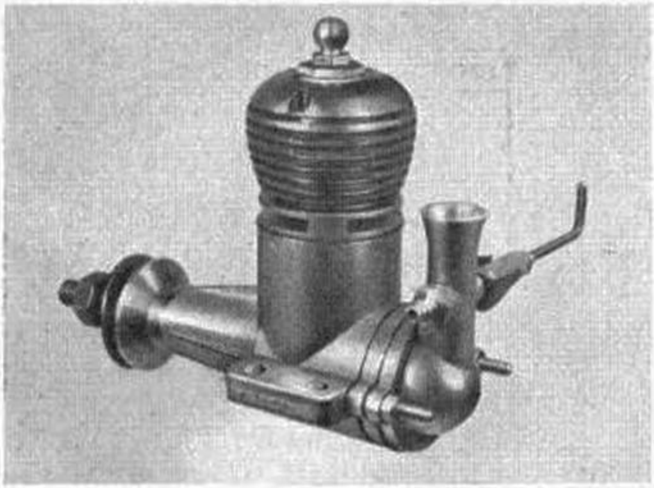

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would appear to suggest that it could be radially mounted via these screws. This, however, we would not recommend as the size of the screws is not really large enough for the size and power of the engine and also the bulkhead would have to be generously cut away to accommodate the rear casting and clear the needle valve.

A possible point with free flight models employing a fuel cut-out to limit motor run is that exact timing may be a little difficult. There is an appreciable delay in shutting off the fuel and the engine actually stopping, during which period the speed will fluctuate. But again this is probably a feature where a satisfactory solution could be arrived at with a little experimenting.

Summarising we would say that the "149" is a most delightful engine which we found particularly free from vices and a pleasure to test. Individual test runs went so smoothly that we had time to spare for a quite extensive series of independent propeller-r.p.m. tests, all the runs being conducted on Frog "Powamix" fuel. No additional nitrating was necessary to obtain consistent running at the very high speeds, but around 12,000 r.p.m. and up a slight increase in r.p.m. was noticeable with a more heavily nitrated fuel.

The "149" would appear capable of giving a good account of itself in every sphere—sports, duration or control line. It is easy to handle, flexible in the extreme and with an extremely good power output. And one further point in its favour—the price is most attractive.

149 Glowplug

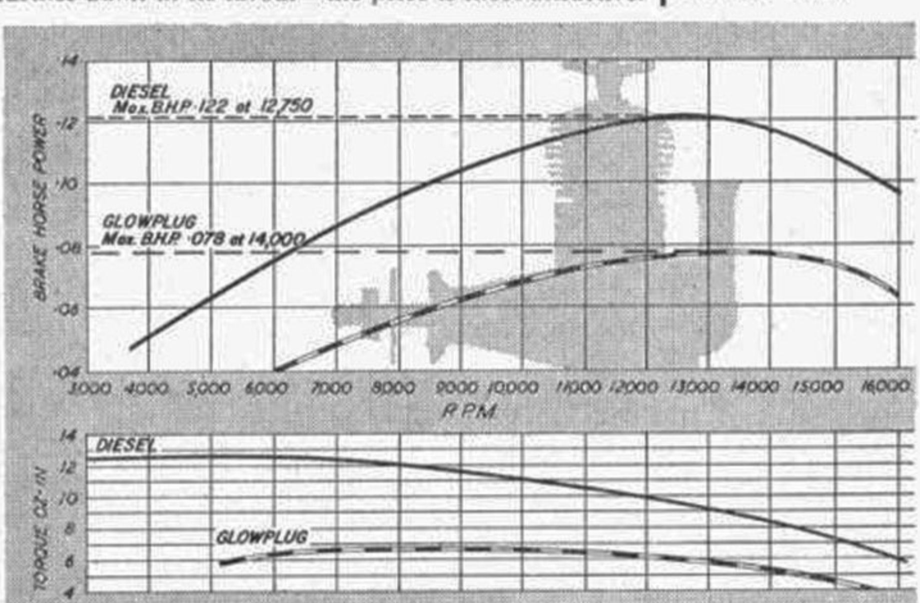
Photo, left, illustrates salient difference in cylinder head.

THIS ENGINE IS identical with the standard "149" diesel, except for the adaptation of the head for glow ignition. The change involves replacing the contra piston with a shaped aluminium insert which has a thin flange at the top, seating on the top of the cylinder proper. The glow plug screws directly into this insert, the whole being held in place by the cylinder jacket (exactly like the diesel jacket, but drilled out with a ½ in. dia. hole to clear the plug). The head insert is sealed with a gasket and it is obligatory that the cylinder jacket be screwed up really tight to eliminate blowing. Also, unless this assembly is tight it will unscrew instead of the plug, when attempting to remove the latter.

The most outstanding feature of the "149" glow is undoubtedly its easy starting characteristics. Provided it is not flooded, it starts with a single flick on any size of propeller. It also starts and runs equally well in either direction, and, particularly with smaller propellers, it is common to find the engine running backwards (at a somewhat reduced speed, it might be mentioned).

The needle valve control is so non-sensitive that finding the optimum setting demands a little patience, particularly on account of the "time lag" between making any adjustment and it taking effect, common to this type of induction. The two extremes are; that if the mixture is excessively rich the engine will suddenly stop abruptly: if too lean it will start to lose speed and die out. Between the two settings there may be several turns of the needle valve on any particular propeller. In this respect, it is quite fun to play with, choking the intake with a finger for a second to make the engine pick up if there is no immediate response to opening the needle valve. The only time the engine gets at all stubborn for starting is if the cylinder is thoroughly saturated with fuel to the extent that the plug is no longer glowing. Finger choking normally provides adequate priming for starting.

Very definitely the "149" glow runs best on plastic propellers. It seems to run more consistently on the smaller sizes.



DIESEL SPECIFICATION

Displacement: 1.49 c.c. (.091 cu. in.).
Bore: .50 in.
Stroke: .460 in.
Bore/Stroke ratio: 1.09.
Bare weight: 3¼ ounces.
Max. torque: 12.5 ounce-inches at 3,000-6,000 r.p.m.
Max. B.H.P.: .122 at 12,750.
Power/Weight ratio: .0375 B.H.P. per ounce.
Power rating: .082 B.H.P. per c.c.

MATERIAL SPECIFICATION

Cylinder: Phoenix case-hardening mild steel.
Piston: Brico centrifugal cast iron.
Contra-piston: Brico centrifugal cast iron.
Crankshaft: Phoenix case-hardening mild steel (stress relieved).
Bearing: Vandervell steel backed sintered bronze sleeve.
Crankcase: LAC 112A light alloy die casting.
Cylinder jacket: Dural, anodised red.
Con rod: Dural forging.
Manufacturers:
International Model Aircraft Ltd., Morden Road, Merton, Surrey.
Retail price **54s. 9d.**

We would say, that unlike the "149" diesel, which is quite happy at any speed, the glow version is definitely best at 12,000 r.p.m. and above and continues to turn over with regularity at speeds well past its peak power output. The latter occurs at 14,000 r.p.m. or some 1,250 r.p.m. up on the diesel version, although the actual power output is lower. Power is, in fact, appreciably lower all along the scale, so that for any particular propeller size r.p.m. is a matter of 1,200 r.p.m. or so down on the diesel version.

The "149" glow will have to be operated fast to get any reasonable performance out of it, with a 6 x 3 wooden propeller seemingly about the right size. Since general running is better on a plastic prop, however, our personal preference would be for a 6 x 4 Frog plastic prop, treated to increase the pitch to some five or six ins. This can be done in the case of the acetate prop by softening in boiling water; or by direct heating (e.g., in an oven) in the case of the nylon prop. Adjusting the pitch in this way to give a static r.p.m. figure of about 13,000 r.p.m. is about right. The "149" glow might also be well suited to ducted fan installations which require a high operating speed for reasonable fan efficiency, and so a high speed engine is to be preferred to one which peaks at a moderate r.p.m. figure.

Probably the most saleable feature of the "149" glow is that its easy starting characteristics label it as "ideal for the beginner". It should be an engine which the absolute beginner could learn to start and adjust with the minimum of time and trouble. It will, quite genuinely start merely by *turning* the propeller over after priming, instead of flicking it, and is in no way vicious. Also it runs fast and makes a "powerful-sounding" noise—even if, in fact, the power output is quite moderate. But there is still ample power there to fly any type of model.

Footnote

Subjected to an arduous works test, two production Frog 149s came through with flying colours. After a total of 21 hours running time the engines were broken down for inspection and showed only very small traces of wear. In fact, to judge by their performance at the end of the run they were just "nicely broken in"! One of the specimens was sent to us for comment and is now towing a 4 lb. radio model around very nicely. The other is going into a "Frog" prototype to start another life of useful service.

The tests were made *without* cooling fins on the cylinders and were conducted in three stages—two continuous runs of 8 hours each on a 7 x 5 propeller and a final 5 hours continuous run on a 6 x 4 Frog nylon propeller. The equivalent of some sixteen cans of fuel was consumed.

GLOWPLUG

PROPELLER—R.P.M. FIGURES	
Propeller	r.p.m.
Nylon propellers	
8 x 6	6,400
8 x 5	7,000
7 x 5	8,400
6 x 4	15,000
5¼ x 4	16,200
6 x 6 (approx.)	12,800
Wooden propellers	
7 x 4 (Stant)	10,400
6 x 4 (Stant)	12,600
6 x 3 (Stant)	12,800
6 x 3 (Trucut)	13,000
9 x 6 (Stant)	5,300

Fuel: Frog "Redglow" plus 10 per cent. nitromethane.

"49" GLOW SPECIFICATION

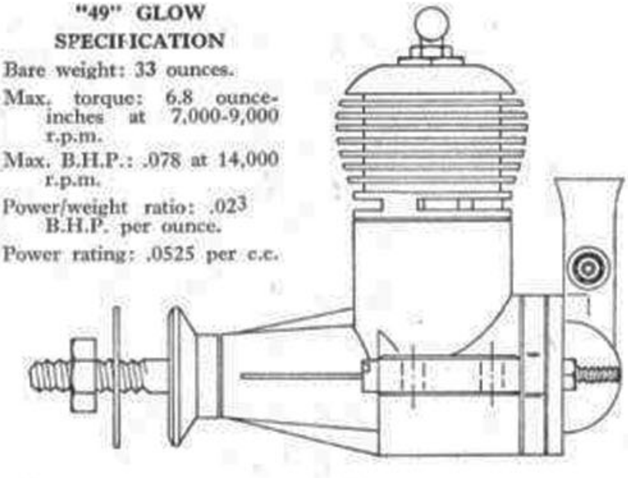
Bare weight: 33 ounces.

Max. torque: 6.8 ounce-inches at 7,000-9,000 r.p.m.

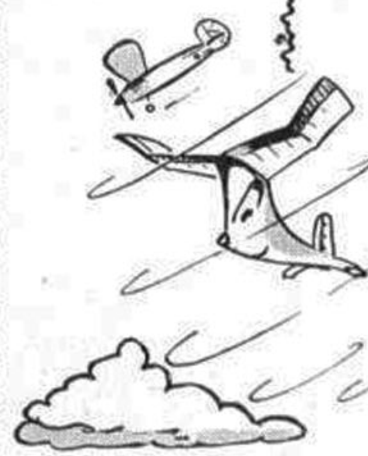
Max. B.H.P.: .078 at 14,000 r.p.m.

Power/weight ratio: .023 B.H.P. per ounce.

Power rating: .0525 per c.c.



What's the answer?



Tony Adams was well out in front of the rest of us with rubber models, although some of us reckoned that he was a bit old-fashioned in sticking to free-wheeling propellers. We had an eye-opener one calm Sunday recently, however, when Tony's new model and a large power job were gliding round together, circle for circle, with Tony's job coming down slower, free-wheeling prop or not! But there's something none of us have been able to fathom. Tony just cannot get a decent glide circle with this design. Offsetting the rudder tab makes it spin in under power and Tony insists on a wide climbing circle because he is not sure of the spiral stability. Try as he may, the glide circle always remains straight! What's the answer?

What would YOU do in a case like this? Think a moment, then twist the page for the solution to the problem printed below.

The Answer:

With a freewheeling prop, *sidethrust* is one of the chief factors affecting the glide circle. A fair amount of sidethrust (to the right) makes it easy to trim for a nice right glide circle. Use little or no sidethrust and some designs are very difficult to make circle on the glide.

A rudder tab is more effective under power than one the glide, so the tab offset needed for glide turn may well be more than it will stand under power. Tilting the tail is generally an effective method of glide trim for turn. Pack up to raise the right tip for a right turn, and *vice versa*. The effect on power trim is not so marked as with rudder offset.