the "pin" is on the counterweight assembly and the slot on that of the vane. If they were the other way round there would be no locking action at all since wind pressures on the vane would merely cause the pin to move in the slot.

To obtain adjustment of the vane angle in the broken condition, side adjusting screws on the top plate, as used for the Ballantyne gear, can be used. This is good since it is both precise and enables slightly differing adjustments for the two tacks. The alternative is to make the pin adjustable in a slot in its mounting arm. Two alternative forms are illustrated. The simple commercial type is a plain clamping screw, but with this it is difficult to obtain precise adjustments. The second is more complex, in which the pin position is adjusted by a screw thread feed adjustment which can be really precise. The latter in practice is worth the additional trouble to make, since to be able to adjust the vane angles critically can make all the difference between the boat "flying" on a course and just sailing there.

Sailing with the Fisher gear is so similar to that with a Lassel or a Ballantyne that only a brief resume is necessary.

When sailing on a close beat (see Fig. 5) particularly if a change of tack or a guy will be required before the course is completed, sail with the gear "broken". That is with the body in the fore and aft position and the locking lever freeing the pin and

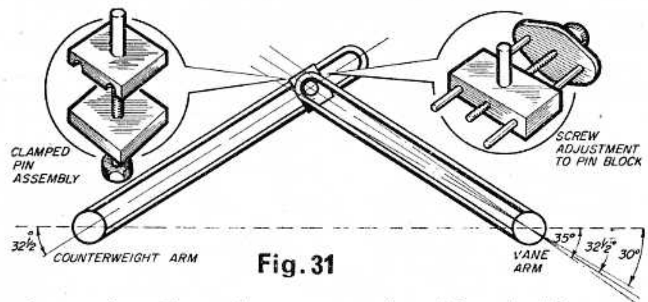


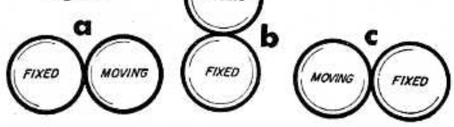
Fig. 31

slot motion. The tack screws or pin setting should have been adjusted in tuning up, before any racing was commenced. It is good practice always to sail close beats with the vane in the broken condition as this ensures that this adjustment is always available, and should there be a wind shift while on a course you are all set for a tack or, with the flick of the guy arm, a guy. All other courses should be sailed with the gear fixed, and the body turned to the appropriate angle. Avoid any temptation to adjust the tacking screws from their optimum setting for a close beat, to sail a course not so close. The settings for a close beat are critical and are worth preserving when once found. Nevertheless, experience may show that slight adjustments are required—for a close beat—in different wind strengths. If required, these are likely to be a slightly closer vane angle in light weather and a slightly greater angle in heavy weather. Quite apart from hull design the rake of the mast can give rise to these variations. It is worth while trying varying the rake of the mast to reduce as much as possible the need to vary the vane angle for different weather conditions since such adjustments and their restoration later can so easily lose adjustment, and know its optimum setting; one of the troubles about vane steering is that the approximate setting of a vane makes the boat behave so relatively well that too many don't bother to seek the most out of it.

Before leaving this gear a few ideas on dimensions will be helpful. While the pattern follows the Ballantyne gear in many details, the replacement of the gear linkage, with its relatively close spacing, by the pin and slot motion calls for a greater spacing between the side pintles on the main body. A minimum spacing of 2 in. between these side pintles is desirable and for 10 Rater and A class 2½ in. would be better. For gears on all but a 36 in. class boat the centre of gravity of the vane and counterweight should be 3½ in. to 4½ in. from the centre pintle, according to the size of the boat. Vane feather sizes will be discussed in a subsequent section. Full use should be made of the space between the side pintles for the pin and slot motion, since the larger it is the more precisely in general it can be adjjusted.

Balance is easily achieved since the vane and counterweight assemblies are so similar in size and construction and the vane and counterweight should be made the same weight, so that their centres of gravity can be equally spaced from the centre pintle. This leads one to point out that it is worth making a couple of vane feathers while you have the gear in pieces and the scales handy, since it is not really good enough to use any old feather if you expect to get the most out of your gear, whatever type it may be.

Fig. 32



THE fourth and last type of gear to be described is the moving carriage gear. This gear as distinct from the previous ones is of British origin and of a later date. In the author's opinion it has much to commend it. It has the following attributes: (1) It is easily balanced. (2) It gives positive helm to Lee and Weather. (3) It is positive in tacking. (4) Its angles of self tack can be adjusted precisely and independently for the two tacks. (5) Its guying action is as good as any. (6) It is robust. That is enough.

The whole principle of operation is entirely different from any of the others and since the author is aware that it presents difficulty to some potential users, it will be described from first principles. To an engineer it is a SUN and PLANET motion, so to start with let us place two pennies on the table side by side, heads facing the same way, in the position of the circles in Fig. 32(a). Holding the left hand one still, with a finger of the left hand carefully roll the right hand one round the stationary one to the position shown in Fig. 32(b) and then on to the position shown in Fig. 32(c) and notice the position of the head. By the time is has got to Fig. 32(b) the head is upsidedown, i.e., it has rotated 180 deg. while moving through 90 deg. relative to the stationary penny and by the position of Fig. 32(c) the head is upright once again, i.e., it has turned through 360 deg. while rolling 180 deg round the stationary penny. Turning now to Fig. 33 the pennies have been replaced by identical gears and the means of rotating the moving gear is supplied by mounting it on an arm, or carriage as we call it, pivoting round the shaft of the first gear. The latter gear is called the SUN wheel and the moving one the PLANET. Moving the carriage either clockwise or anticlockwise while holding the sun wheel will cause the moving gear, the planet, to behave just as the coin did. The gear will turn through twice the angle that the carriage moves through. Now we couple the sun wheel to a rudder which, for a start, is held central relative to the axis of the boat, and we mount a vane feather and counterweight on the planet gear, in line with the carriage and the gears and the rudder. This is illustrated in Fig. 34. Consider for a moment that the rudder is fixed in line with the skeg and we move the carriage through 15 deg. to one side. The vane will move through 30 deg. Just what we want for our self tack motion. If the carriage is moved 15 deg. in the other direction the vane moves 30 deg. in that direction. Now think of the carriage being temporarily secured in the 15 deg. position and free the rudder; any movement of the vane will be transmitted through the gears to the rudder as a positive drive either to LEE or WEATHER. That is just how the moving carriage gear works. To give the carriage the required movement it is coupled through a cord 'bridle" to the main boom, and to adjust the vane

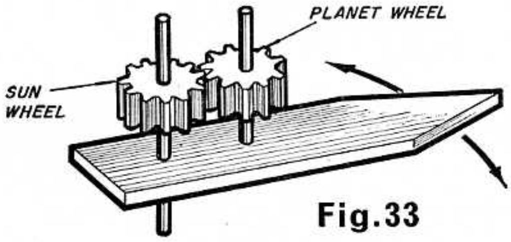


Fig.33

angle on the tacks adjustable stops are put on each side of the carriage to determine and limit its angular motion.

Fig. 35 shows the details of a practical design based on these principles. A moving carriage vane gear was first described by the author in the *Model Maker*, Febru ary 1961, and let it be said that there is nothing wrong with that design—the present one is merely a variation on the theme, just as one gets variations with the other forms of gears. Turning to the parts as coded in Fig. 35 "A" is the rudder post with quadrant for gybing just as with the previous types of gears described, "B" is the main pintle on which the gear is mounted, "C" is the carriage which fits on the main pintle. It consists of a tube "H" which is a reasonable fit on to the pintle and has in its top a conical bearing. Carefully spaced a pitch diameter of the gears away from the centre of the tube is the pintle "D" to carry the planet wheel "E". This wheel is fixed to a tube "K" with a top conical bearing. The scale is clamped to this tube to permit final adjustment for fore and aft alignment when the gear is fitted to the boat. The vane and counterweight assembly also fits on tube "K" with an adjustable clamp which permits it to be adjusted for correct frictional movement when the gear is being used in the fixed condition. The sun wheel "F" carries the arm "G". This combination is made a

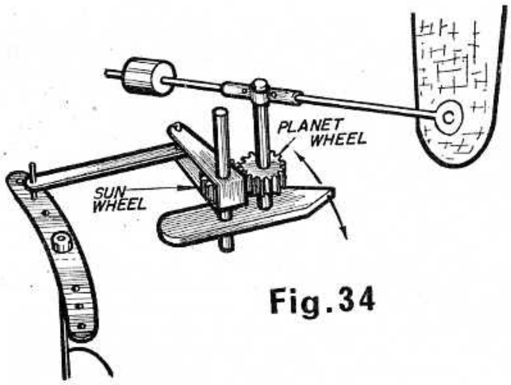
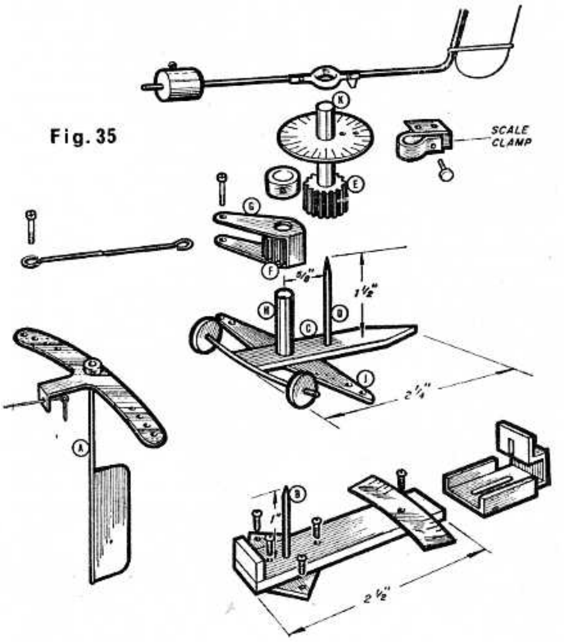


Fig.34

Fig. 35



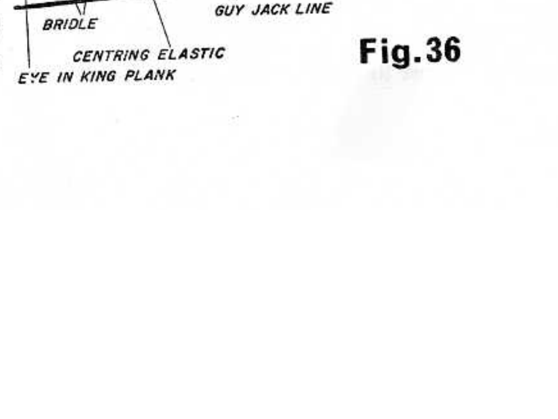


Fig.36

nice clearance fit on tube "H". The arm is designed at the gear end to cover the gear teeth so that it will prevent the tube, on which the planet wheel and vane are mounted, lifting off when in use. It also acts as a limiting stop. The sun wheel is in turn prevented from lifting off by the collar above, secured by a grub screw. The cross arm "J" used for giving the tacking motion is secured to the carriage at the pivoting point. The gear motion is transmitted to the rudder via a push pull rod attached to the arm on the sun wheel at one end to the quadrant at the other. The angle of movement of the carriage when in the "broken" or self tack condition is determined by the two stops which are on the threaded rod attached to the carriage. They "catch" on a stop on the main base. At the other end of the main base is a scale for observing the angle of the carriage—this is half the vane angle as will be apparent from the introductory remarks. The locking catch is also at the back end of the base in the form of a slider which, in the forward position, engages the tail pointer of the carriage. The vane and counterweight assembly will be clear from the figure. It has centrally a friction grip on the tube to enable it to be positioned at any angle while gripping enough not to change angle with wind forces. Fig. 36 is a plan view showing how the bridle of Terylene cord connects the beating sheet from the boom to the tacking bar on the gear. It also shows the guys which will be described in the operation of the gear.

Having now described the parts we turn to the alignment on a boat. The fact that a push pull rod is used to transmit the vane movement to the rudder permits much greater flexibility in positioning the vane gear relative to the rudder post compared with the pin and slot motion usual with other gears. Thus on 36 in. R and Marbleheads where the rudder may be very near the transom the gear may be mounted less than an inch away, while on a 10 R or A class the opportunity can be taken to place the gear well aft of the rudder post so clearing the vane from the slipstream of the mainsail. A gear using equal sized gear wheels has been illustrated and the author would recommend this 1:1 ratio, having experimented with different ratios up to 3:1 (the larger gear being the sun wheel and the smaller one the planet. He is however aware that others find satisfaction with a higher ratio than 1:1. When using the 1:1 it is recommended that the distance of the point of attachment of the push pull rod to the quadrant from the rudder post is one and a half times the length of the operating arm on the gear. This has practically the same effect as a 1½:1 gear ratio with equal spacings for the push pull rod. If you have more than one position on the quadrant you can find what suits your boat and gear best. Having decided where you wish to place the gear, the length of push pull rod can be measured from the point on the quadrant you are going to use (with the quadrant and rudder neutral) to the pivot on the gear arm held at right angles to the centre line of the boat (if the alternative positions on the quadrant are on an arc from this point then you can effectively alter your ratios without any other adjustment). It will then be found that the range of angular movement of the gear arm will give adequate rudder movement, more than is available with a pin and slot motion. This angular movement is limited in one direction by the arm striking the back tube and in the other direction by the gear end of the arm stopping against the teeth of the planet wheel.

Having fitted the right length of push pull rod and secured the base of the gear to the deck with the locking catch in the locked position the scale should now be adjusted so that the 0 deg. marking is aft and the 180 deg. forward relative to the axis of the boat. With the rudder held central, unlock the catch and see that the vane moves to twice the angle as indicated on the carriage scale as the carriage is moved from the central position first to starboard and then to port. Adjust the carriage movement to 16 or 17 deg. on each side by turning the stops.

OUR attention can now be directed to the bridle which gives the tack motion, the guys and the centering line. First the bridle. This should be of nylon or terylene so as not to be affected in length by being wet or dry. It requires to have just a degree of slackness about it so that when the boom is moving over and pulling there is no binding at the eyes or pulleys. Three methods are illustrated. (a) in Fig. 36 where the beating sheet is hooked to a cord link to an eye on the centre line of the boat and the two halves of the bridle come from the top of the link. (b) Fig. 37a where a horse (possibly existing) is used and the two halves of the bridle are attached to the runner, and (c) Fig. 37b where a plain bridle is used and the length carefully adjusted, with the kicking strap to the boom tight, so that it has just the right amount of slack. The latter is the simplest, but has the disadvantage that it is so easy to adjust the kicking strap for some other purpose and then find that the bridle is binding. The author would therefore recommend (a) or (b).

The guys are simply light elastic bands connected at one end to the cross arm of the gear and at the other to bowsies on side jack lines, so positioned that there need be no pull on the elastic, i.e. it is out of action, or when moved forward there can be considerable pull, i.e. the guy is in action. Both are out of action on plain tacking.

With this type of gear the author recommends a centering line to a forward tail on the quadrant, so that if the wind fails the rudder is centralised immediately. With the earlier types of gears described it has been desirable to apply the centering action to the gear body because of the pin and slot linkage to the rudder, but that limitation does not apply to the push-pull arrangement. This centering elastic should be shirring elastic, nothing heavier, it only has to centre the rudder when the wind fails and anything stronger means that the vane has to continually waste steering power "fighting" this elastic.

Now to using the gear. Let us start with any plain course. In these cases the carriage is locked and the vane set to the angle for the course, see Fig. 5. Either the beating sheet or running sheet is used as appropriate. The gear will transmit positive lee or weather helm. Gybing lines should be set as described in an earlier section if the course is anywhere near a run.

For a close beat where a tack or a guy may be required the vane/counterweight assembly is set fore and aft over the scale (VANE aft) and the carriage released by sliding the lock back out of engagement. If the carriage tacking stops have been set as described earlier the gear is all set for port or starboard tacks with both guys slack, and for turning from one tack to the other. If one is sailing on the port tack, i.e. wind over the port side, and on turning the boat to starboard when it comes to shore, wishes it to guy back to port tack then the starboard guy is tightened —hard for a short guy and less so for a long guy and depending on the strength of the wind. Clearly for a guy from starboard tack to port tack the other guy is used. When sailing with the gear broken the wind in the mainsail holds the carriage firmly against its stops and LEE or WEATHER helm is applied positively as was the case with the gear fixed. There is nothing more to it. It is as simple as that.

The influence of vane gears on yacht designs

Before commenting on design features of vane gears in general, to facilitate your own experimentation we will devote a short section to the influence of the introduction of vane gears on yacht design and hull design in particular. As was mentioned earlier, the practical application of vane steering gears had to wait many years because of the gaff rig sail plan and the short waterline, large sail plan, designs that were usual. The Bermudian rig gradually became more popular in the 1920's. We should therefore look at designs of that period. Here again the form of steering then used by model yachtsmen, the Braine gear, had been in use many years to influence hull designs. These may be described as hulls of good balance since the gear was not normally used on the beat and designs having a large lateral plane, particularly in the fin and skeg, were usual. This feature was necessary to counter the power of the Braine steering on other than the beating course. To this end, also, the rudders were long horizontally and shallow. If they had been otherwise, a puff of wind would have turned the boat off course. The shape of the rudder and the slipstream of the water past it smoothed out irregularities, but the large lateral plane and long solid skeg made the boat sluggish to turn. These features are illustrated in Fig. 38. These were the conditions when the vane was introduced. It took a long time for designers and skippers to realise that radical changes had to be made to designs to meet the requirements of the new gear. Many a vane has been thrown in the pond, to the author's knowledge, in disgust at its inadequate performance, when, in fact, it was the hull design that was unsuitable. Many old boats are performing wonderfully well today, having been modified by cutting away the centre of the skeg, deepening it, and fitting a tall slim rudder as shown in Fig. 39. Note the forward angle of the skeg. It took some courage for a skipper of the old school to modify a good boat, by the old standards, to this extent to prove that it would perform still better with a vane gear on it, but it just had to be done to get the best out of the new gear. If your boat has these old features don't be afraid to tackle the job, it will be well worth while. One reason that these old boats still put up such a good performance when modified is that the hull in other respects was so beautifully balanced.

The vane gear operates on all courses and operates on wind direction and not strength. It is capable of exerting a much smaller force, relative to the Braine, and consequently a much more tender hull design is required. This is done by having a much smaller fin. In fact this is reduced as much as one dares without losing too much by drift on beating and reaching courses. The skeg is cut away from behind the fin, which gives a freer flow for the water to get away when driving on the beat well heeled, but a small skeg is positioned immediately in front of the rudder, serving to part the water and give it directional flow about the rudder as well as providing the rudder base bearing. Since a rudder and skeg combination well aft will give a good turning moment for little force, it is now usual to place the rudder as far aft as the water line of the design will permit. Because hull balance with a continually effective steering gear is not so important, and so many full sized craft are clearly unbalanced, there seems a current tendency to pay less attention to this feature than was so necessary in the past; only time will tell whether this radical change has been justified. Since a balanced rudder (without a skeg in front) should theoretically require a smaller controlling force for the same turning moment on the hull there would appear to be scope for experimentation here. The author is aware of one such successful design, but the same designer failed to achieve a satisfactory performance on other boats, so while there is a field for experiment it is not an easy one.

The high aspect ratio Bermudian rig sail plan has been developed concurrently with vane steering and while perhaps not directly related to the introduction of vane gears, the new lateral planes of

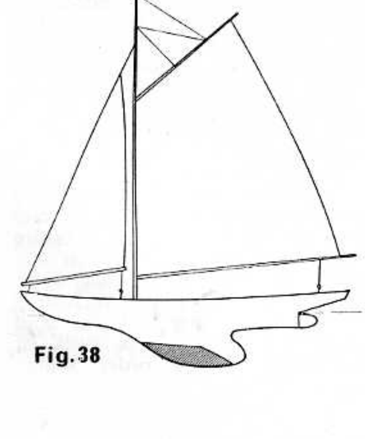


Fig.38

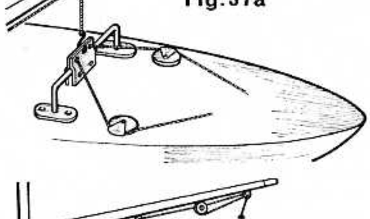


Fig.37a

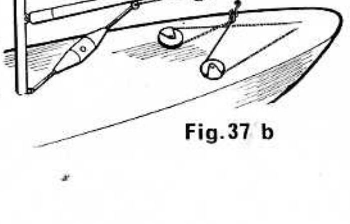


Fig.37 b


Fig. 39

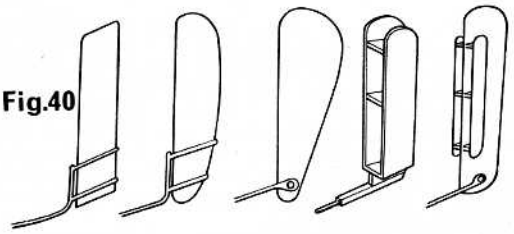


Fig.40

hulls, tall sail plans and vane gears are interrelated or interdependent.

Design features of vane gears

This section is one of odds and ends, hints and tips. It is in no particular order since as the author sees it there is nothing particular to give it order.

Perhaps what you have been hoping for are some ideas on vane sizes, that is, the feather, more than the gear itself. One might expect that its size would bear some relationship to the rudder it has to operate. This is undoubtedly so, but the ratio of areas can vary quite widely and is influenced by the length of the arm carrying the vane and the proportions of the rudder, rather than its area. A tall narrow rudder will operate effectively from a relatively small vane on a long arm or a larger vane on a shorter arm. The rudder size has almost certainly been given by the designer of the hull. Starting from there it is suggested that with a long arm, a vane of six times the area of that of the rudder would be about right while on a shorter arm, eight times would be required. What is a short arm and what is a long arm? For a 36 in., 2½ in. would be short, 3½ in. long. Marblehead 3 in. short, 4 in. long. 10 rater 3½ in. short, 5 in. long. "A" Class 4 in. short, 6 in. long.

The vane or feather should be made of obeche, 3/32 in. thick for the smaller ones and 1/8 in. for the larger. With the thicker material some aerofoil shaping can be given, while for the thinner material remove the square edges. As to the shape of the vane, one has only to look at those at a Championship match to realise that either it doesn't matter a great deal, or we haven't yet settled what is the right shape. On the average a six to one ratio of height to width is of the right order and a little shaping can be done to make it aesthetically more pleasing. It is much more important to have a balanced vane/counterweight combination than some mathematically calculated vane size. It was stressed in earlier sections the importance of being able to set the vane (feather) in the balanced position. This is stressed again now. The author is in favour of using a feather with a straight vertical front edge and shaping the aft part if you wish. Suggestions are given in Fig. 40. The vertical front edge is believed to create a good low pressure area on the lee side and this, together with the direct pressure on the windward side, gives a good operating torque. The vertical forward edge also enables one to see at a glance if the feather is in the correct position for balance. It will be noticed that the "boxkite" and "aeroplane side vent" types are included. These are seen perhaps as experimental types, too liable to damage in a collision for everybody's fancy but as types which are effective they should be recorded. Their purpose is to reduce weight by more effective form, so if you are going to experiment bear in mind that the size (total area of surface) should be less than the conventional feather for the same power.

A NOTE now on pin and slot motions. It was mentioned in an earlier section and must be reiterated here that whenever a pin and slot motion is used the pin must be on the driving member, thus when it is used between the vane gear and the rudder the pin is on the vane gear and the slot is on the rudder (quadrant). When used between the feather and the counterweight the pin is on the counterweight side since it is the counterweight moving over under gravitational force that moves the gear over from one tack to the other.

Pintles and bearings deserve special mention because the free operation of any gear is almost certainly dependent on its bearing surfaces. Pintles can be divided into three classes. Vertical with the point upwards on which something is "hung", vertical with the point downwards which is supporting something, and pintles with a point at both ends supported usually between conical cups. The former two both require a second bearing surface which is usually a bush or sleeve bearing. Bush or sleeve bearings are types where there are parallel surfaces in contact.

In the author's opinion they can be put in the following order of preference: (1) The vertical pintle with the point upwards, with a small area of bush bearing near the base. The taller the pintle and the greater the distance between the point and the bush at the base the better, Fig. 41a. (2) The double pointed pintle, operating between conical cups whose distance apart can be precisely adjusted, Fig. 41b. (3) Carefully proportioned bush or sleeve bearings Fig. 41c and (4) The vertical pintle point downwards Fig. 41d. This is the last because of the relatively high bearing, point "X". A glance at the illustrations of the gears described will show the situations in which the various forms are used. Top and bottom pintles are definitely recommended for rudders.

A word now on "fits". This is an engineering term relating to the closeness with which the parts fit together. Let it be emphasised that for satisfactory vane gear operation under all conditions—especially after a few dippings in salt water—a slack fit must be used. The author is aware of numerous precision engineer-made gears that "gummed up" very quickly in the above mentioned conditions because water is not a good lubricant. It is also particularly important, if you are going to have your gear plated after completion, that adequate allowance be made for the thickness of plating. If you are going to sail frequently in salt water it is well worth while having your gear chrome plated. In other circumstances it is nice but rather expensive to have done.

Free movement of the gear under all conditions is of paramount importance. It should be such that wafting a newspaper six feet away will cause it to operate. This means clearance fits not only on pintles and bearings but also on pins in slots and the meshing of gears. These features will show up on the bench as backlash or slap in the overall movement. While this should not be excessive, it is of no detriment when of the appropriate order, since when sailing—and this is important—the gear should be set to be giving a minute amount of helm and therefore the slap is taken up. Additional wind pressure in the same direction is against a firm motion and in the other direction the removal of that small amount of helm immediately starts the correcting movement. It should be appreciated that the wind moves constantly more degrees than the slack of your mechanism if it is of the right order. Watch the weathercock on a tall building. The author passes daily the London weather centre and watches their weathercock, and its gyrations are amazing. Where possible avoid side pulls on bearings. The centering line is a particular case where the elastic can pass through a hole in the member being centred, whether it be a tail on the gear or quadrant, and side pull practically eliminated.

Gears (of the toothed variety) when you use them, should be of the best cut teeth you can readily lay your hands on, although Meccano gears have been used and proved adequate. Avoid meshing them too tight—a bit of sand or grit can play havoc with their performance in those circumstances. For guys and centering lines, shirring elastic, obtainable at Woolworths or any haberdashery store, is recommended. It can be obtained in more than one thickness and the textile covering preserves the elastic well. Otherwise, use elastic bands which are very cheap. Some people use fine stainless steel springs, and these are excellent until they are accidentally overstretched when you are in much more trouble than if you carry a packet of elastic bands.

Hard brass is recommended for the construction of vane gear mechanisms. A look round the curtain rail counter at Woolworths will furnish quite a variety of pieces. Hard soldering, using Johnson Matthey Easyflo flux and No. 2 solder with a Davi-Jet obtainable at about 5s. from any good tool shop, will give a most robust job and with a little practice, is not difficult. Parts screwed together and then soft soldered is a second best, while soft soldering only can hardly be recommended at all, particularly if salt water is to be encountered. Too often has the author seen soft soldering let down a skipper at a crucial moment in a race. One sees other materials used in the construction of gears such as Perspex, Formica, Tufnol, and aluminium. Because they are not so strong as hard brass, greater cross sections of material are necessary for adequate strength which makes the gear more bulky and it is not so easy to get robust joints. The author has tried most with varying degrees of success but today favours BRASS.

The Vane in Full Size Practice

It is proposed to close this series with a few notes on Automatic Vane Self Steering applicable to full sized craft. This would be presumptuous but for the following two reasons: (a) It cannot be denied that it is model yachtsmen who have experimented and developed over many years this form of steering. (b) That famous single handed ocean racer Francis Chichester sought the advice of members of the author's club before equipping *Gypsy Moth III* with "Miranda" for his single handed ocean racing. In these circumstances the author humbly feels some justification in making the following observations.

To those skippers who have followed the series, it must be evident that, though we may appear to be wishing to do the same thing, our problems, while having a similarity, are in fact quite different, and it is hardly correct to say we are trying to do the same thing. As was pointed out in the section in the March issue, the complications of the racing model yachtman's gear are brought about by the tacking and guying requirements to avoid being penalised in racing to the M.Y.A. rules.

Basically then, vane steering for the full sized yacht can revert to the non-self-tacking gear which is inherently much simpler. Nevertheless, it is quite clear from reading and thinking about the requirements of the full sized boat that there are many problems. The first is that one cannot manage a "feather" of anything like the proportions we use on model yachts. The second is that few, if any, designers of full sized craft achieve anything like the balance that has for so long been a characteristic of our models. How far the resolution of the vane steering problem will await different, one almost says better, hull designs with accompanying sail plans remains to be seen. There may well be a parallel here to the introduction of vane steering to model boats designed round the requirements of the old Braine steering. The changes required may be just as radical.

One point that should be emphasised to our big brothers from the outset is that vane steering, as conceived for model boats, steers the boat at a constant angle to the apparent wind, and it is inherent in its conception that it does not steer a compass course. It cannot because it is wind operated. Within the author's knowledge a device to sail a fixed compass course—which would be very useful to model yachtsmen as well as full sized—would require "apparatus" which would contravene model sailing regulations, and no doubt full size.

Turning now to the problems of physical design, we will first deal with the below water aspects. Much depends on the position of the rudder on the hull, i.e., whether it is on the transom or hung on the fin, either vertically or inclined but well tucked under and, of course, whether the transom is vertical or inclined. Just as we model yachtsmen had to change our underwater forms to obtain maximum advantage from vane-steering so it may yet be found that this is necessary in full size practice, particularly as regards hull balance and developing partially balanced rudders which do not require such great effort to operate them, i.e., they have a proportion of the blade forward of the rudder post. The positioning of the rudder to obtain maximum turning moment with minimum effort, as is so frequently met with our Marblehead designs, is an important factor in the overall design.

Three basic rudder arrangements seem to offer practical solutions, namely (1) a plain rudder, whether it be the boat's present rudder, or one more suitable for vane steering—see the changes made in model design between Braine and vane steered boats —situated at the optimum point under the hull body. A partially balanced rudder situated well aft is the author's opinion, unless the fin is narrow, when the hull is tender to steering from a long narrow rudder placed on its after edge. (2) An auxiliary flap or rudder on the after edge of the boat's main rudder. Because of the difficulties of operating such a device on a main rudder tucked well under the hull, this arrangement is more applicable to a rudder well aft and projecting beyond the transom or actually hung on the transom. (3) An independent supplementary rudder associated directly and only with the vane mechanism. This can be

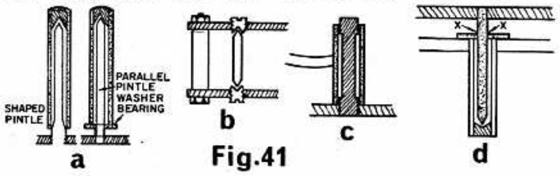


Fig.41