A DAILY EXPRESS PUBLICATION 5s.

EXPRESS AIR RIDER HANDBOOK

SECOND EDITION

Outline plans for a new

TWO-SEATER SPORTS HOVERCRAFT

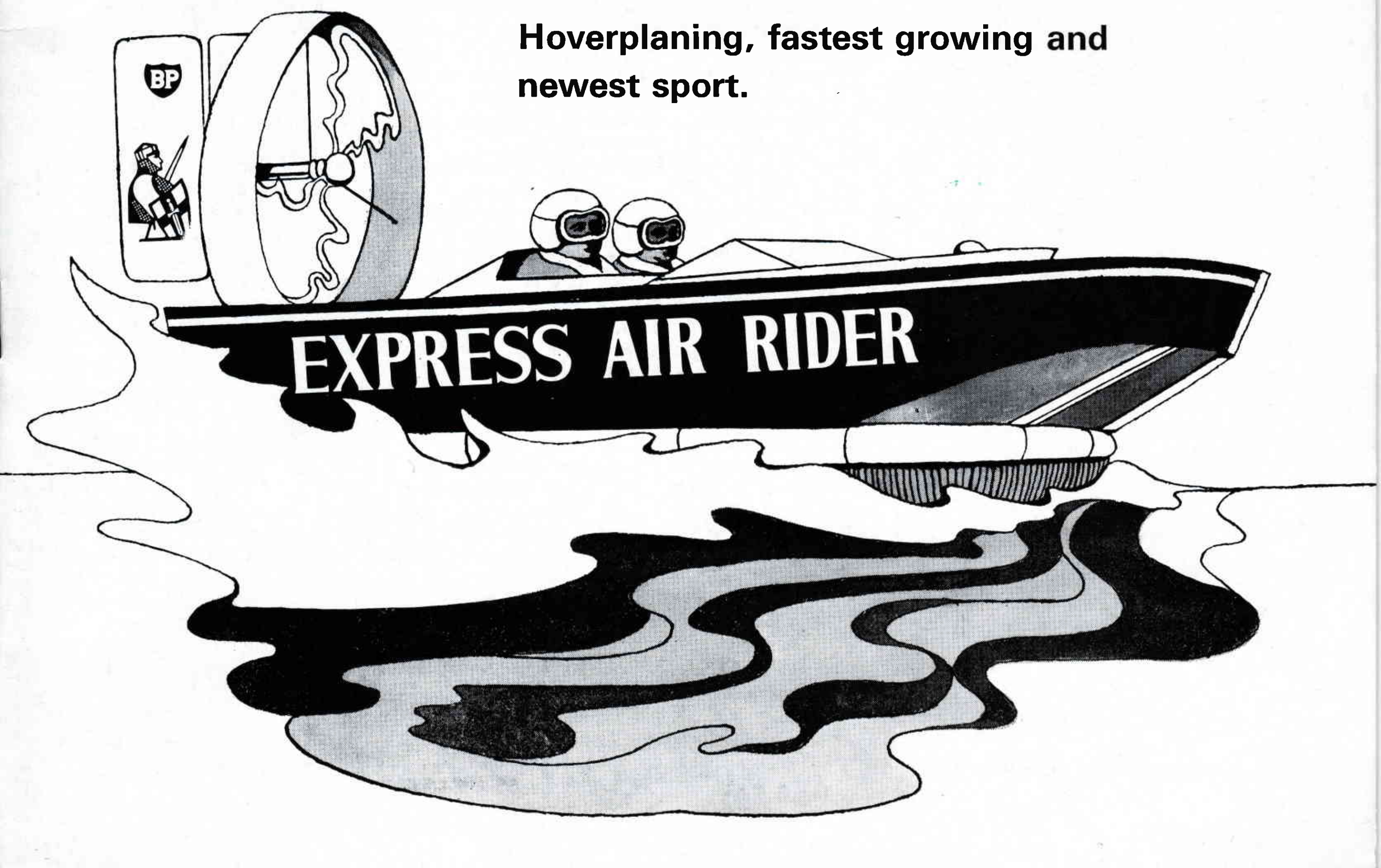
Designed especially for school group construction.

Details on how to build and how to hover.

Safety regulations, certification of craft, insurance.

What the Hoverclub does.

Hoverplaning, fastest growing and newest sport.



This year's Schools' Hovercraft Competition organised by British Petroleum Ltd. was a big success. Pictured here are the three winning Express Air Riders built by Rossall School, Macefields Secondary Modern School and Burnt Mill Comprehensive School.

HOW IT BEGAN

THE DAILY EXPRESS began pioneering amateur hovercraft racing and building when there were less than eight practical light craft in existence. Today there must be several hundred either built or under construction. Next year the official Board of Trade estimate of the number of light hovercraft will rocket to 800.

Not only was the "Daily Express" the first organisation to support the small group of enthusiasts who formed the Hoverclub of Great Britain and boost hoverplaning into a popular new sport, but we encouraged the amateur constructor.

Just as the amateur aviators built and tested their crude flying machines at the turn of the century we coaxed the garden shed genius of today to turn his attention to the great new "wheel-less carriage" revolution.

Since our campaign started, the Hoverclub's membership has multiplied ten-fold. Since the "Daily Express" single-seater Express Air Rider first appeared in 1966 it has become the most famous light hovercraft in the world. To back up this apparently extravagant claim consider first the television audience figure.

A staggering 270,000,000 viewers have seen the little blue and white craft perform on land, on snow, on water . . . and even under it when once it somersaulted during marine trials. It has appeared on T.V. networks in Canada, the United States and South America. In both black and white and colour. Commentaries, translated in nearly every language in Europe, told viewers about this "Daily Express" project.

Cinema audiences in South Africa, Australia, New Zealand and all over Europe have seen Express Air Riders in action.

In Britain, the racy blue and white craft has been seen on national network T.V. programmes varying from "Magpie" to "Tomorrow's World" to "Tom Tom". In several appearances on British newsreels total audience figures of 38,000,000 have already been reached.

Newspaper and periodical coverage has been worldwide. The Express Air Rider was the only non-commercial hovercraft to appear in the first volume of Jane's transport reference series devoted to hovercraft. It has even been assessed in a general study of hovercraft in Britain for the Canadian Government.

All this results in an ever-growing demand for information. After the first 5,000 "Daily Express" readers had asked hundreds of different questions about this new form of transport it was decided to meet this demand for basic knowledge with a small handbook. And so the "Express Air Rider" handbook was produced. Within three months the entire first print had been sold. It was another successful "Daily Express" first—the first handbook to bring hovercraft building down to a simple easy-to-comprehend level.

Aimed primarily at the younger generation who plan to tackle building a craft as a school or club project, the primary considerations had to be high safety and low cost. Building costs vary greatly but they do compare favourably with the expense of producing the average go-kart or sailing dinghy.

Already this craft has become most popular and construction projects are under way in many parts of the world. Some are being built in Canada and America in East Africa and Western Australia, even in the Malayan jungle. And in Britain scores of schools and youth organisations have the matter in hand. One school is already putting together a second Express Air Rider.

The youngsters who now experiment with this craft may well become the hovercraft designers of the future. Today's hovercraft experts are either ex-aeronautical or ex-marine engineers. The true hovercraft engineers, unbiased by accepted aircraft or shipbuilding practises and theories will come from today's schoolchildren.

And today's hovercraft experts are the first to admit that the fresh new science of hoverdynamics must benefit from fresh new thinking. The kind support they have given to this publication is proof indeed.

Edited by JOHN VASS

Illustrated by LEONARD CLOW

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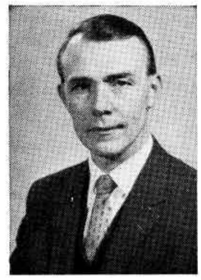
SOME WORDS OF ENCOURAGEMENT TO THE AMATEUR BUILDERS FROM

THE INDUSTRY PIONEERS

Dr. Christopher Cockerell, Inventor of the hovercraft: "The hovercraft belongs to the younger generation anyway. I wish them well".



Richard Stanton-Jones, Managing Director, British Hovercraft Corporation: "In years ahead this new industry must be developed and expanded by the school children of today, so it is good that they are now learning about hovercraft".

Ronald Shaw was the first civil servant to see the potential of Cockerell's discovery and give his Ministry's support. Now a professional hovercraft consultant, Mr. Shaw needs no words to give this project his support . . . he is chairman of the Chiltern's Hover Club who intend building an Express Air Rider.

Leslie Colquhoun, Managing Director, Hoverlloyd: "I am delighted schools are being encouraged in this way. After all, they will produce the next generation of hovercraft scientists and engineers and those who will develop this great British invention".

Peter Lamb, first hovercraft test pilot in the world, Chief Commander, British Hovercraft Corporation: "Anything you send out into the amateur world is always improved upon. A keen amateur interest in hovercraft is good for hovercraft development generally".

Norman Piper, Managing Director, Hovermarine: "All hovercraft fascinate school children so it should be a popular subject in any school programme and they are the people who will be joining us one day".

John Watford, Sales Manager, Vosper-Thorneycroft Hovercraft: "I wholeheartedly approve of this project to get youngsters taking 'O' and 'A' levels to move on to 'H' levels. It is an exciting new subject"

Christopher Bland, Managing Director, Hoverwork Limited: "Present times are difficult times in the hovercraft industry so we need all the support we can get and that includes the youngsters".

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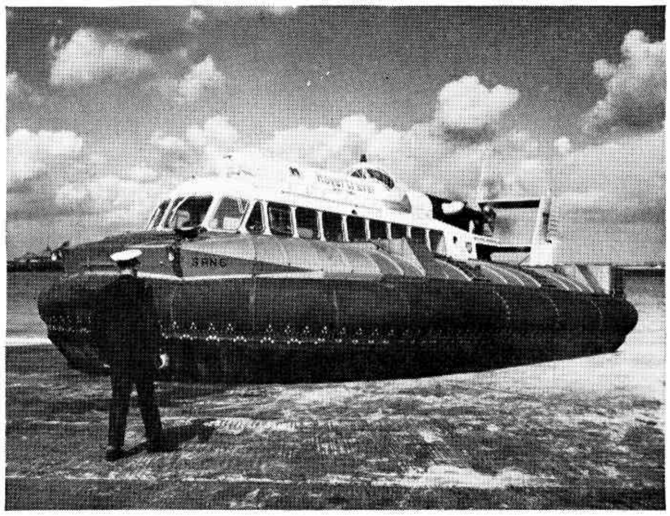
WARDEN (SR.N5) CLASS



WINCHESTER (SR.N6) CLASS

WELLINGTON (BH.7) CLASS

MOUNTBATTEN (SR.N4) CLASS

HOVER HISTORY

The hovercraft was once Top Secret Government property. Only a handful of military chiefs, senior civil servants and a few scientists and engineers knew how it worked.

Now anyone can know. Not only that, but with a couple of old motor-cycle engines, some wood, a fan, propeller, sundry bits and pieces of metal and material for the skirt, anyone can build their own hovercraft.

There is no longer any air of mystery to riding along on a cushion of air. It is a revolutionary discovery and the development of the "wheel-less carriage" will be exciting.

Yet, like many other great discoveries, it is basically simple. The pneumatic tyre amazed a generation, but what small boy cannot repair a cycle puncture?

There is nothing complicated about making an aircraft wing for a light plane when the principles of flight are known. Again, look at the vast numbers of small boys who design and fly their own models.

And so it is with hovercraft.

Follow a few basic rules and there is no reason why anyone who can use the average household tools cannot build a successful hovercraft. It may lack in efficiency but it will work. Experiments to improve the efficiency of big commercial hovercraft are just as necessary for the professionals as they are for the amateur with his tiny two-seater.

And the amateur could easily find ways of improving performance which have evaded the most talented team of scientists, just as the amateur aviation pioneers provided the great advances in the development of the aircraft.

That is what makes building and testing amateur hovercraft so exciting and worthwhile.

The brainwave of some garden shed genius could solve many development problems faced by the professionals looking ahead to 2,000 and 3,000-ton craft in the future.

And they are the first to admit this. That is why the crowds at amateur hovercraft rallies are liberally peppered by the leading men in Britain's hovercraft industry.

That is why they have welcomed the "Daily Express" scheme to introduce hovercraft building to schools and commended our campaign to make hoverplaning a popular amateur sport.

You Begin Like This...

First accept the fact that the most important part of a hovercraft is the part nearest the surface over which it is travelling—be it sand, swamp, tarmac, snow or water.

That part is the skirt. The job the skirt has to do is two-fold. It has to seal the gap between the rigid base of the hovercraft and the ground so that too much air cannot escape and it has to keep the craft balanced.

It must do all that, and yet cause as little drag as possible as the craft moves across the ground.

A craft weighing say 400 lb., and about ten-feet long and six-feet wide, can be pushed across a lawn with one finger if it has a well tailored skirt. If the skirt is inefficient you would have to put your shoulder to it. That is the sort of difference—all the difference in the world.

Secondly, consider the part next nearest the ground. This is the part of the craft which contains the air cushion and also the reserve of air necessary to cope with any sudden losses from the bottom of the skirt as it goes over obstacles or rough terrain.

This compartment is called the plenum chamber and this is supplied with air from a fan. So long as the air flows in smoothly and out smoothly through the skirt, it is doing its job. The less the restriction to the air flow—it should not have to force its way through narrow slits or tiny holes—the smoother it will be.

Thirdly, there is the fan which provides this air. The need is for a great volume of air but not a great pressure. In fact, the cushion pressure of the average amateur hovercraft varies between 8 lb. and 10 lb. per square foot.

There is no doubt that a good centrifugal fan can better an axial fan at doing this job, but it is heavier, more complex and more costly. These are the three good reasons why we have avoided them.

The most important of these three reasons is weight. This is in fact Rule Four.

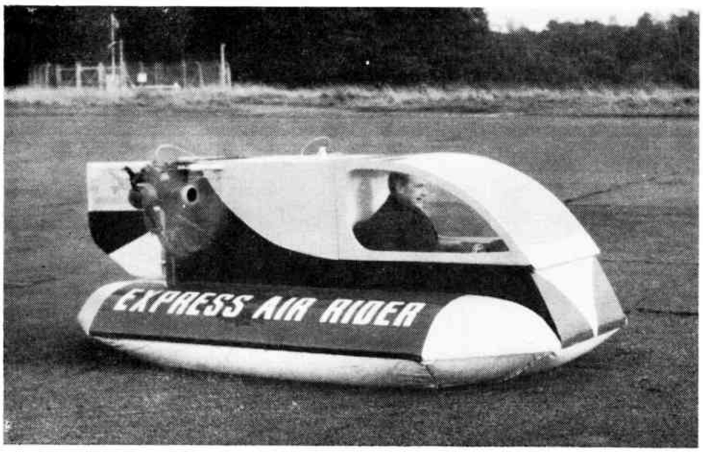
In a giant bulk tanker, an extra 100 tons makes scarcely any difference to its performance, because its power to weight ratio is a thousand times better than that of a hovercraft. In aircraft, the power-to-weight ratio is vital. In hovercraft it may not be vital, but it is very important.

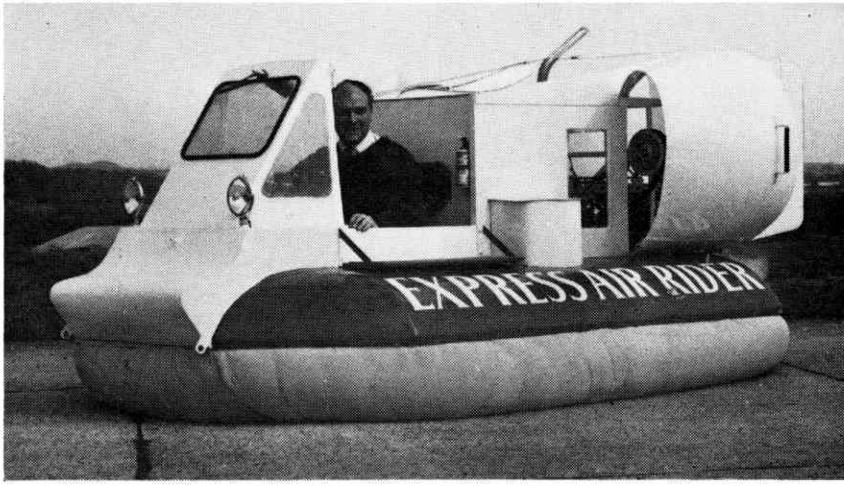
This means that hovercraft have to be light. Engines are heavy but they produce power. Headlights, fancy seats, solid footrests, and thick timber all add up to a considerable weight and do not produce power.

The Fifth Rule is to avoid air starvation. The fan which provides the air cushion cannot suck in enough air if something blocks the flow of air to it. The propeller, which produces the thrust to move the craft, cannot do its job if the flow of air to it is obstructed. If some piece of superstructure must be built then it is always less damaging to the airflow to put it behind the fan or propeller.

The Sixth Rule concerns the hull of the craft. If it is to be used over water as well as on land it will have to behave like a boat should the air cushion collapse and decay. No boat has yet been built that can hit the water at 20 knots with a squared flat front.

As hovercraft can skim across the top of the water sideways, consideration has also to be given to this factor.





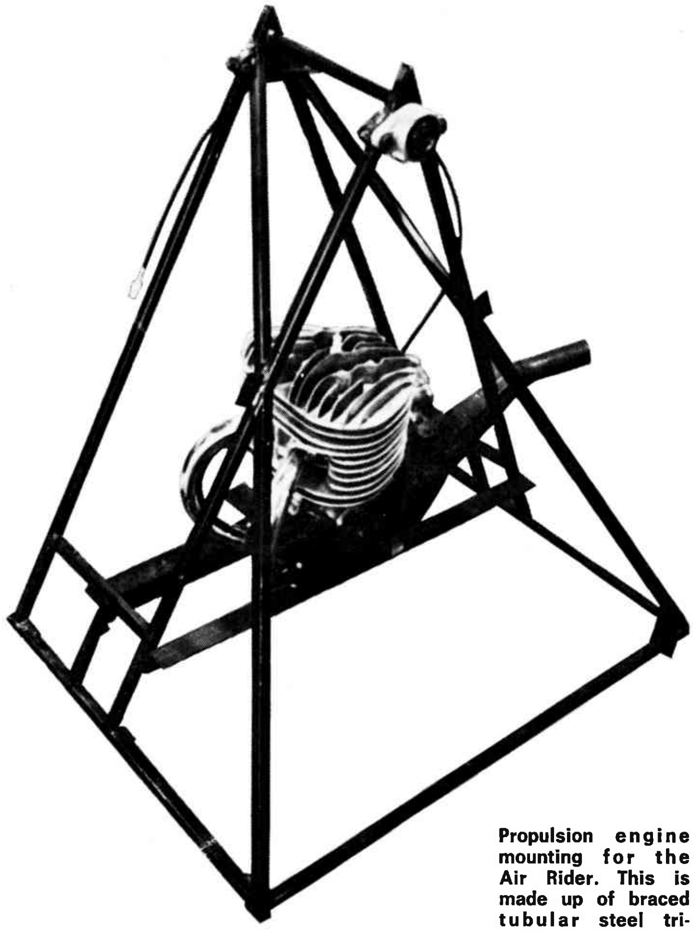
November 6th, 1966. The first public demonstration (above left) of the first Express Air Rider. (Above right) The original Air Rider after considerable modifications including the addition of about 60 lb. of glass-fibre, elaborate ducting of the propellers, and the addition of a small bow shape and a new windscreen with wiper. Even headlamps were fitted. In this form the craft proved to be far too heavy and much of the extra weight, including most of the glass-fibre, was stripped away.

CHANGING SHAPES OF THE EXPRESS AIR RIDER

After modification, the craft appeared as shown above and was so light that early on a Sunday morning John Vass took the machine "over the hump" for the very first time. He is pictured during the historic run at Bembridge, Isle of Wight. During the 1967 rally season the Air Rider appeared as shown on the left, with triple rudders and yet another bow shape. In this form it put up good performances in the competitions.

Two years' experiments eventually led to the development of the latest version of the Air Rider as it is today. This latest model is larger and more powerful than the earlier versions so that it has accommodation for a crew of two instead of only one. The lines of the hull have been improved and the single large propeller gives more thrust than the two smaller ones did. It is this craft you will learn how to build by reading this book.

BUILDING THE CRAFT



Propulsion engine mounting for the Air Rider. This is made up of braced tubular steel triangles.

Hull Construction

Putting the hull together can be done in a dozen different ways and there need be no set order after the main side formers are cut out and held 36 inches apart. Between these formers goes the floor, cabin front, rear of the cabin, bow former and buoyancy box under the rear engine mounting. Fix these by marking out their positions on the main formers, fix all joints first with fillets of 1 × 1 timber—Pirhana pine is knot-free and quite light. Screw and glue in position. Once the front and rear of the cockpit are fixed in place, the hull becomes a rigid structure.

Then on the outside of the main formers again fillet screw and glue the air duct formers, two on each side. Fix the stern piece, which in effect forms the rear of the craft, and the rear engine deck and vertical $\frac{1}{8}$th ply buoyancy box vertical panel. Leave the bottom of the buoyancy box open and when the craft is upside down fill it with blocks of expanded polystyrene or similar buoyant material.

Put on the front bow and two side bows. The main structure is then ready for the engine frames. Reinforce the parts of the main former which supports both the lift engine and rear engine frames with aluminium or $\frac{3}{8}$th timber plates. Put the outer skin of $\frac{1}{8}$th ply around the side of the craft.

Once the engines have been installed along with the electrical and fuel systems and the lift engine duct and fan, cut a lift engine inspection panel in the top skin close to the lift engine duct. This gives access to the carburettor and wiring and enables plug changes to be made without stripping off the fan.

Fit the ply skin to the upper bow section of the hull. The top decking is simply joined to the side skin by stitching with short strips of copper wire and then sealed inside with a glass-fibre bandage. After twisting the wire tight with pliers, the glass-fibre jointing is made and when dry the protruding ends of wire are snipped off.

Attach the skid strips to the main formers, line the inside of the craft skin with two-inch thick panels of expanded polystyrene to give buoyancy, and the hull is ready for waterproof sealing and painting.

Note. A fairly heavy ply was used for the side formers in the prototype only because we allowed for heavy wear and tear during trials. There is no reason why very thin ply or aluminium sheets, properly braced, could not be substituted. The important parts of the hull are the front and side bow plates. They prevent the craft from nosing in should a "plough-in" or other conditions develop over water. Because we also wanted to use the craft in sea water we used the resin-bonded "Aquaply".

Engine Mountings

Nothing looks quite so unsurmountable as the job of attaching a misshapen thing like a motor-cycle engine to a flat piece of wood.

If the frame of the machine is available then it can be cut to form the basis of the mounting. Otherwise, start with some lengths of $\frac{1}{2}$-inch and one-inch square tubing.

The lift engine mounting does not face the stresses of the thrust engine mounting so it can be comparitively simple. It can be two lengths of one-inch tubing laid horizontally across the craft and slotted into the two main formers. It can even be secured with split pins.

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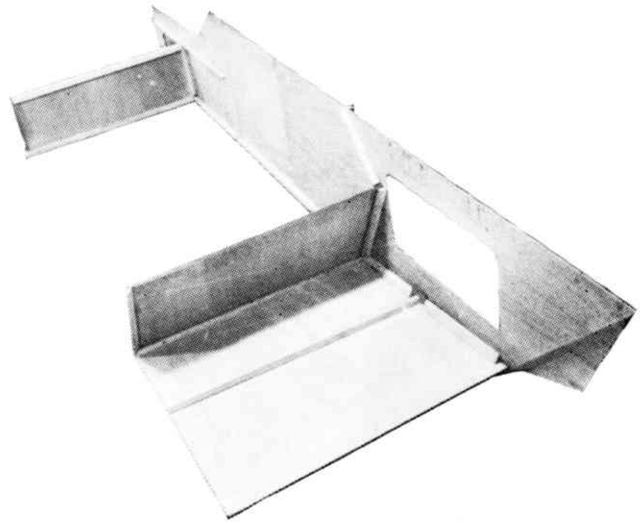
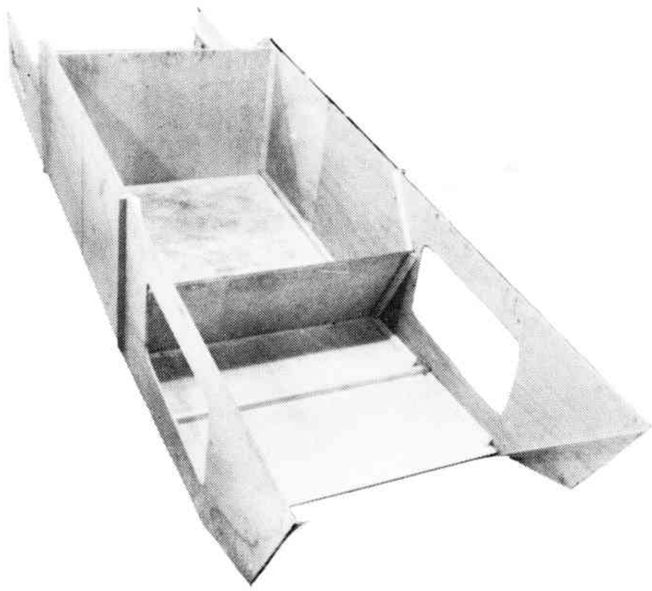
On the advice of the Schools Council, who support this project, certain stages in the construction are left to the initiative of the individual. This leaves scope for the inventive builder to try out new ideas of his own.

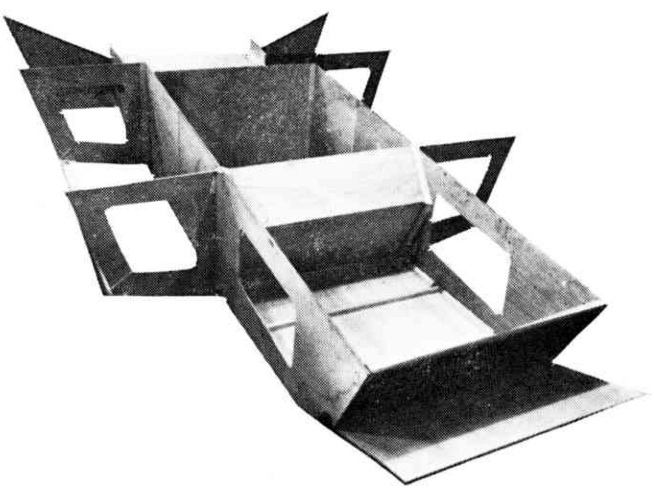
HULL ASSEMBLY



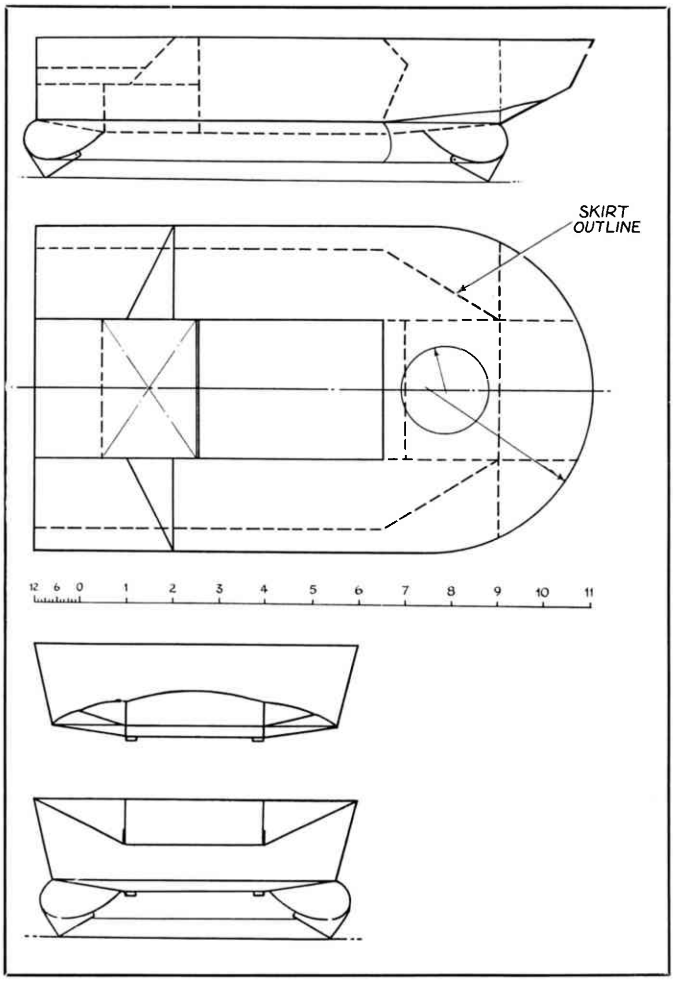
One main side former in position with the lift engine floor, cab footrest and one wall of the rear buoyancy box attached.



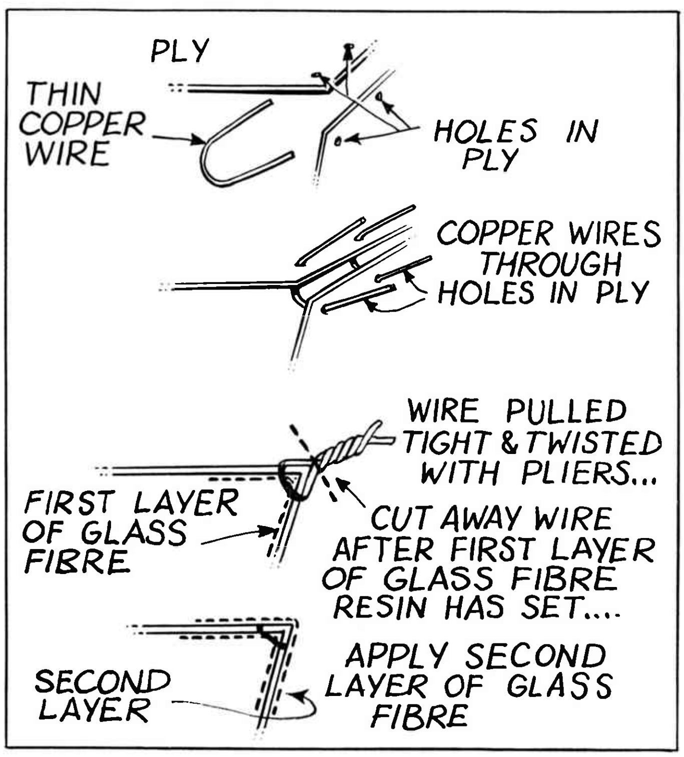
Both main formers in position with cab floor, rear cab panel and bow supporting panel attached.



Flat front bow panel and side members in position. The side members and top of the craft are then covered with a thin ply skin, stitched at the edges with soft copper wire. The joints are glass-fibred.



The above drawing shows the basic shape of the Air Rider showing the position of the skirt, lift fan duct and propulsion engine platform. The scale on the drawing is marked in feet and it will be seen that the craft measures 12 ft. long by 6 ft. across the beam. The drawing below shows in detail the method for the glass-fibre joints in the hull construction.



Building the Craft

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Hold the engine in the position you want it—with the drtving shaft about six inches below the highest point of the foredeck—and measure up the size of struts necessary to hold the engine in this place.

These struts can be attached to the base of the crank-case and the cylinder head bolts. Have at least three securing points on the engine. The two lengths of tubing can be attached together with a cross-base once their distance apart has been determined by the shape of the engine being used.

This engine has the job of turning a 22-inch fan which is mounted directly on to the driving shaft. A boss to fit the shaft to which the fan can be bolted can be made on a lathe or turned out in almost any machine shop.

However, if there is a chain cogwheel on the shaft it may be of sufficient diameter to fit the fan hub and then only a few bolts are needed.

The fan will rotate at about 2,000 to 2,500 r.p.m. continuously. Apart from starting and stopping, it will run at a constant speed.

The thrust engine mounting has an important job. The stresses on it come from all angles and frequently from three or four points at once, so it has to be strong.

First, it has to support an engine up to 350 c.c. turning out 20 brake horse power. Then it has to support the propeller shaft with a propeller as big as those used on light aircraft!!—on one end and a drive pulley on the other. Belts between the engine pulley and the propshaft pulley are always under tension and when power is transmitted through them the dominating effect is to pull at the propshaft pulley and try to force it sideways; when the power is cut, the general effect is reversed. The forward pull developed by the propeller which moves the craft can be 150 lb. or so. Thus another major force on the frame. Spinning at 3,000 r.p.m., the propeller develops considerable gyroscopic effect and every time the direction of the craft alters—either up, down, left or right—the propeller tries to continue in the original direction.

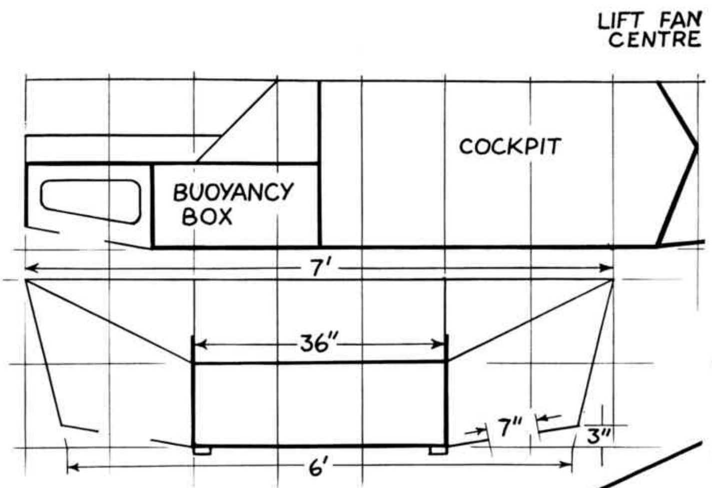
Also, there is the torque effect which tries to force the craft to rotate in opposition to the engine and propeller. It does not succeed in doing this but the frame must stand up to the force.

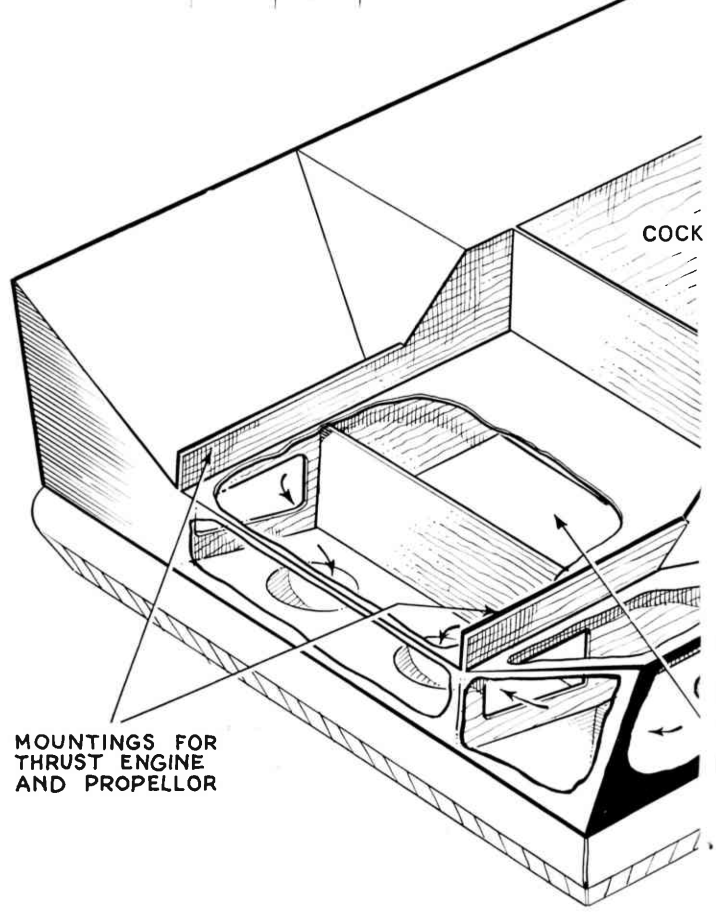
After all that, it must be a surprise to learn that a frame made from half-inch square tubing can survive all that. It can if it is properly braced.

The easiest way is to start on the outside and work inwards. In other words, draw up two triangles with flat tops. The tops have to take the propshaft bearings. Place them 14-inches apart—wide enough for any motor-cycle engine. Then brace the two triangles together at each of the four corners. Fit a plate slightly oversize for the plummer block bearing mounts and drill to take the plummer blocks. Ensure the blocks are perfectly aligned. The bearings, which are self-aligning, allow some tolerance, however.

Then engine has to be mounted as low as possible in the frame to keep down the centre of gravity, so get someone to steady it on an inch thick length of tube placed across the two bottom cross braces between the flat-topped triangles.

Then move it until the drive shaft protrudes from the rear flat-topped triangle sufficiently to give the pulley it carries a half-inch clearance beyond the frame. Measure up for the supporting struts between the engine and the



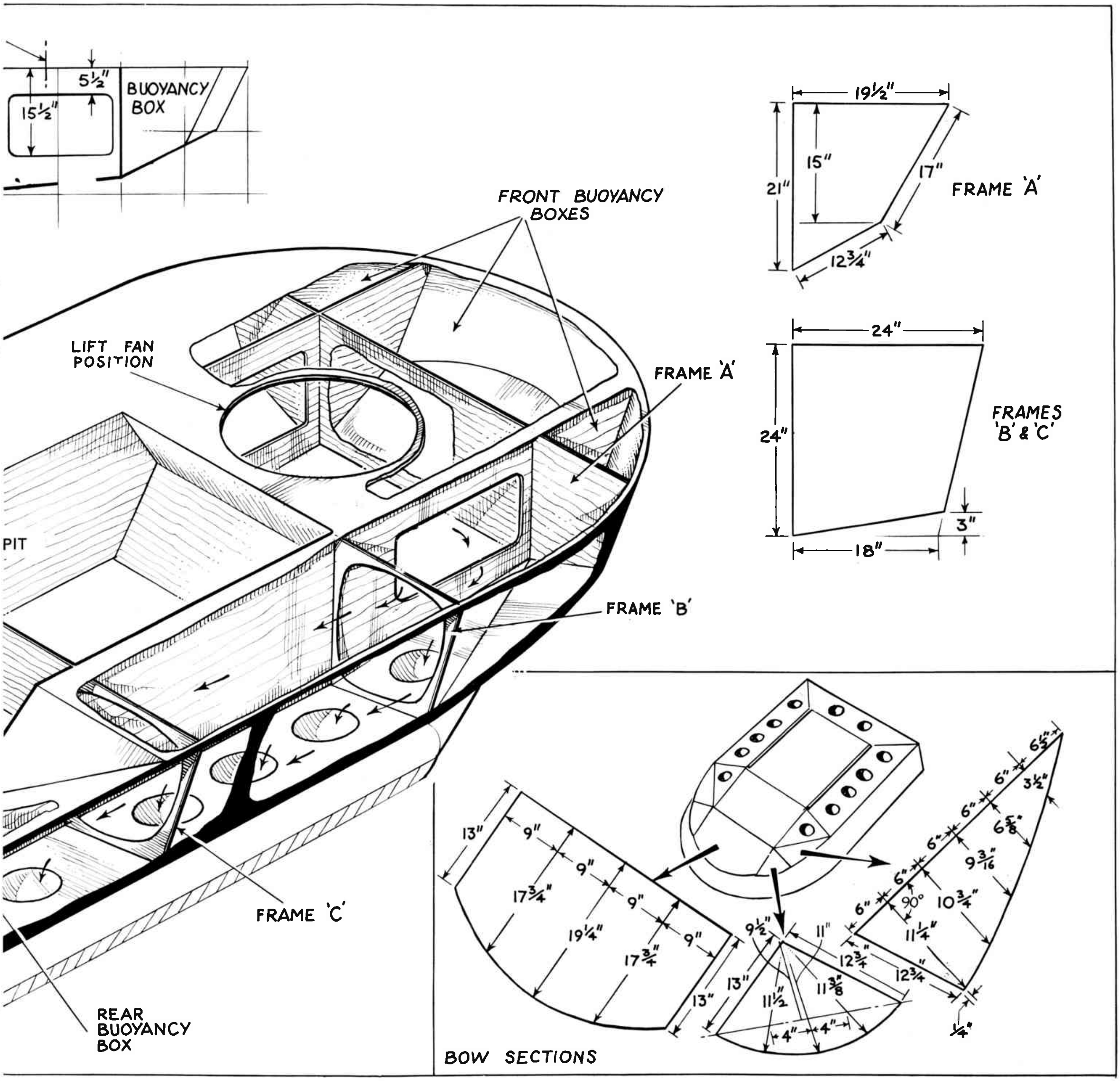


two bottom cross braces. Bolt on the one-inch tube supporting the weight of the engine. Add another two supporting struts between that tube and a securing point on the engine.

Now add two diagonal braces linking the two flat-topped triangles. Avoid any protruding parts of the engine and allow for exhaust pipe and carburettor.

The angle is not precise but they go from the base of the rear flat-topped triangle to somewhere near the top of the front (propeller end) flat-topped triangle.

Now test the frame by allowing two strong fifth-formers to try to twist it out of shape using their hands and feet—kicking is not allowed—with the engine, but not the



propeller shaft, in place. If they succeed, then add braces or angle plates where any weakness has shown up. Check all joints again after this pummelling.

Before mounting this frame to the craft reinforce each side of the main formers at this point with thin metal plates, then bolt on. Four bolts on each side is enough.

The Propeller Shaft

The propeller shaft can be turned out of a solid block of steel, or you can use a standard motor car half-shaft!! Half-shafts are ideal; they are rejected by the motor industry when the splines on the end of the shaft become "chewed". This is the part that the school hovercraft industry do not want anyway. The important thing is that the shaft has no flaws and there is a good wide flange on the other end. If in any doubt, use a new half-shaft.

Fortunately, most half-shafts for cars are one-inch thick so some work with emery cloth is all that is needed to produce a good propeller shaft. The end with the splines can be sawn off and prepared for the drive pulley.

Ensuring that the shaft fits the bearing is the most precise job in the whole project. A simple guide is to make sure it is not rubbed or ground down so that the bearings just slide on. It has to be an interference fit so tight that you need a wooden mallet to tap them on. There is a nil tolerance on the oversize limit of the shaft. Undersize limit must not be more than 0.001 inch.

(continued overleaf)

Building the Craft

(cont. from previous page)

Check shaft diameter, ensure ends are free from burring and lightly coat with oil. Slide the bearing on to the shaft and position. Then align bearings and bolt plummer block units firmly to frame. Use ⅜th inch high-quality steel bolts. Slide the locking collar up to the bearing and rotate it to engage the eccentric surfaces. Grip collar firmly and twist in direction of rotation so that the parts lock together and grip the shaft. Then tighten the collar set screw with an Allen key.

Before you do assemble the shaft the propeller has to be mounted. And it has to be mounted true, which is the next most precise job in the whole project.

The use of self-aligning bearings compensates for any slight misalignment in the frame. However, great care should be taken to ensure the shaft is a good fit. The actual bearings we used were Fenner sealed transmission units. These handle shaft speeds up to 2,100 feet per minute which is equal to a one-inch shaft spinning at 8,000 revs per minute or a two-inch shaft at 4,000.

Propeller Drive

The first engine used in the prototype was a 360 c.c. Greeves which turns out 30 brake horse power at over 6,000 revs per minute.

The propeller's efficient speed is half that. Thus the pulleys must be of different sizes. We chose Timing Belt pulleys. They use toothed belts which do not stretch and one belt can cope with the job. This of course cuts down weight—always a primary consideration. As the pulleys have teeth, the calculation is easy. By putting a pulley with 18 teeth on to the engine shaft and one with 36 teeth on to the propeller shaft we have the 2 to 1 reduction required. The pulleys are secured to the shafts by taper locking collars.

The toothed belt does not give the stretch problems encountered with some other types. They have glass-fibre cores so are very durable. This is important since they travel at more than 4,500 feet per minute. Loss of power in transmission is also reduced to a minimum with this type of belt and there is no belt slip.

But sometimes lack of belt slip is not the blessing it seems. Because of the "punch" from the Greeves' power unit we had to use simple "V" belts to provide some flexibility between the engine and the thrust propeller. When we tried out toothed belts the rigid link caused a succession of troubles with shaft keys shearing at every trials session.

Rudders

The size, shape and number of rudders required can be left to the individual. There is no real need to have an aerodynamically balanced rudder in a light hovercraft because it does not contend with high wind or air pressures.

A twin or triple unit is recommended, but whatever you use remember that a sheet of thin ply, suitably braced, or a light frame covered with linen or plastic sheet will do the job. It is simply hinged on an upright support behind the propeller. With a multi-rudder, only one of the units need have a control arm—the other units can be linked with short lengths of rod. The control arm is there to take the cables which run on pulleys down the craft to the control column.

One of the simplest forms of control columns can be made from the handlebars and bearings of a scrapped cycle. The front forks and the crossbar and other frame tubes are sawn off, and the bearing is clamped to the front of the cockpit. The handlebars need shortening to a total width of twelve-inches—this gives adequate purchase—and a stub arm or pulley has then to be fitted to the handlebar shank to accept the control cables from the rudder unit.

To improve the flow of air, a fixed fin may be fitted between the rear of the propeller and the rudder unit—but again this is optional.

Air and the Air Cushion

The air around us presses against everything with a force of 14½ lb. per square inch. This is the weight of a column of air one-inch square from surface level right to the top of the earth's atmosphere.

Of course the actual weight of a cubic foot of air at 25,000 feet is approximately half that of the same amount of air at ground level (about 1¼ ounces), because the upper layers compress it.

This is not a preface to a lesson in elementary science but to offer a comparison with air cushion pressures. These can be as low as a few pounds per square FOOT. The Schools' Air Rider will, with one adult, weigh around 600 lb.

The area of the cushion—basically the width of the craft multiplied by the length contained within the skirt—is 6 ft. by 10 ft. equalling 60 square feet with the fingered skirt and slightly more with the simple bag skirt.

Simply divide the weight by this figure, which gives a cushion pressure of about 10 lb. per square foot. This is a tiny fraction of normal atmospheric pressure. It gives some idea of the comparatively low air pressure needed to provide a very powerful air cushion.

Even the giant hovecraft operate with an air cushion pressure of much less than half normal atmospheric pressure.

To go back to the Schools' Air Rider, the cushion pressure required is not high enough to burst a good paper bag. This is an important point for those inclined to add surplus strengtheners of one sort or another.

Skirt

There are two distinct schools of thought on skirt material. One group opts for the heavy duty fabric which withstands the effect of ground abrasion by the sheer thickness of the material. The other supports the use of

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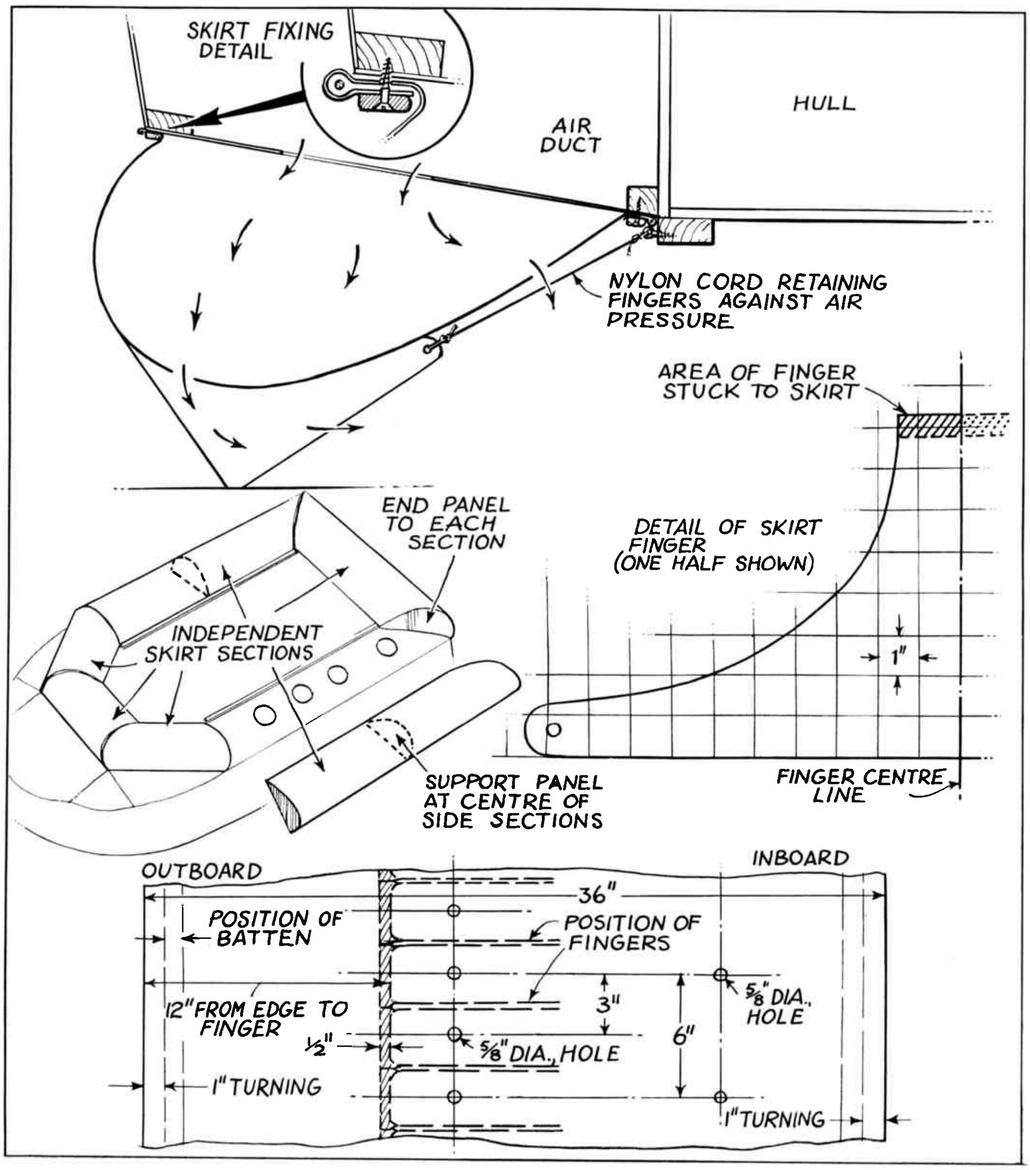
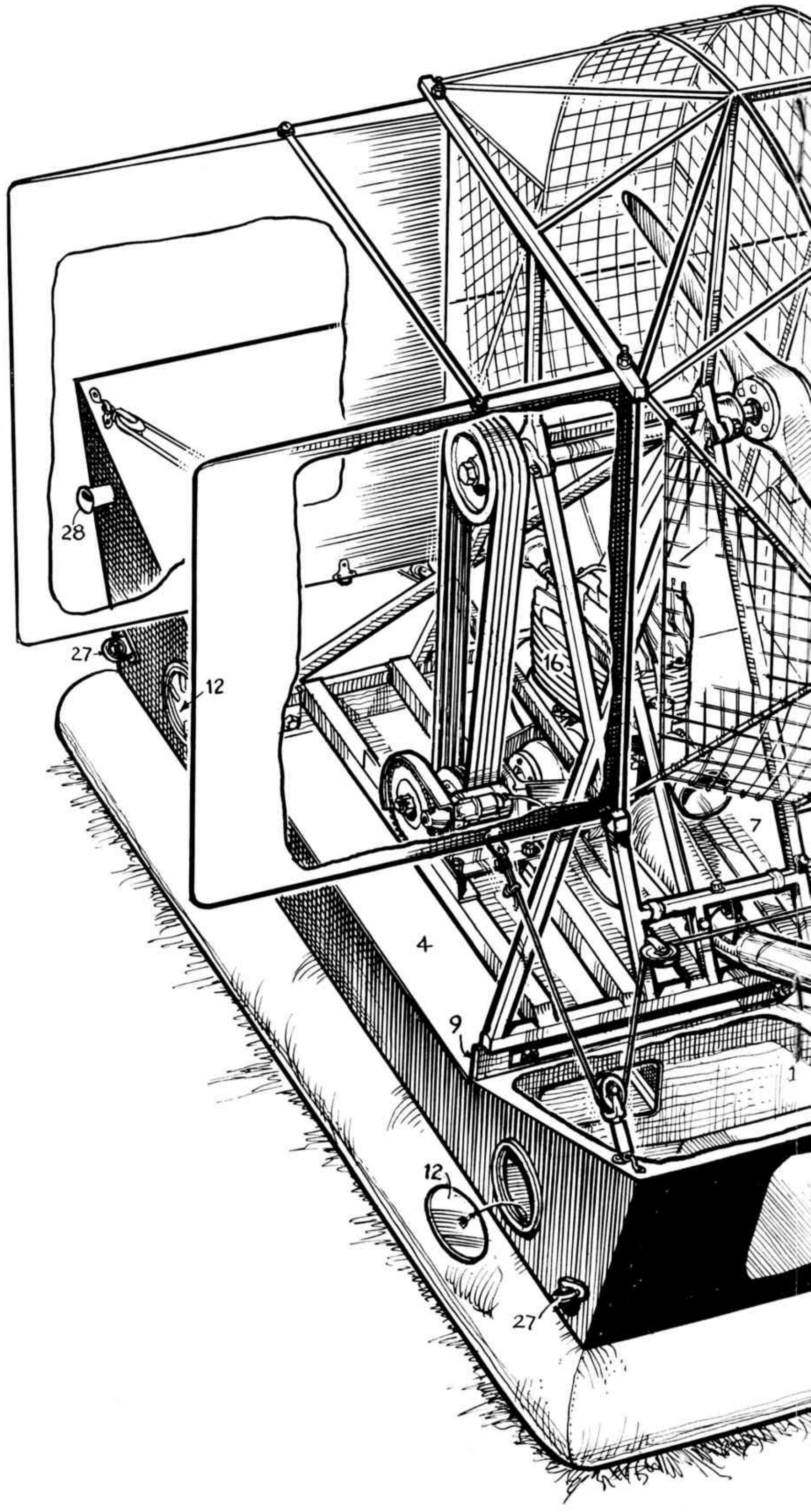
FITTING A FINGERED-BAG SKIRT



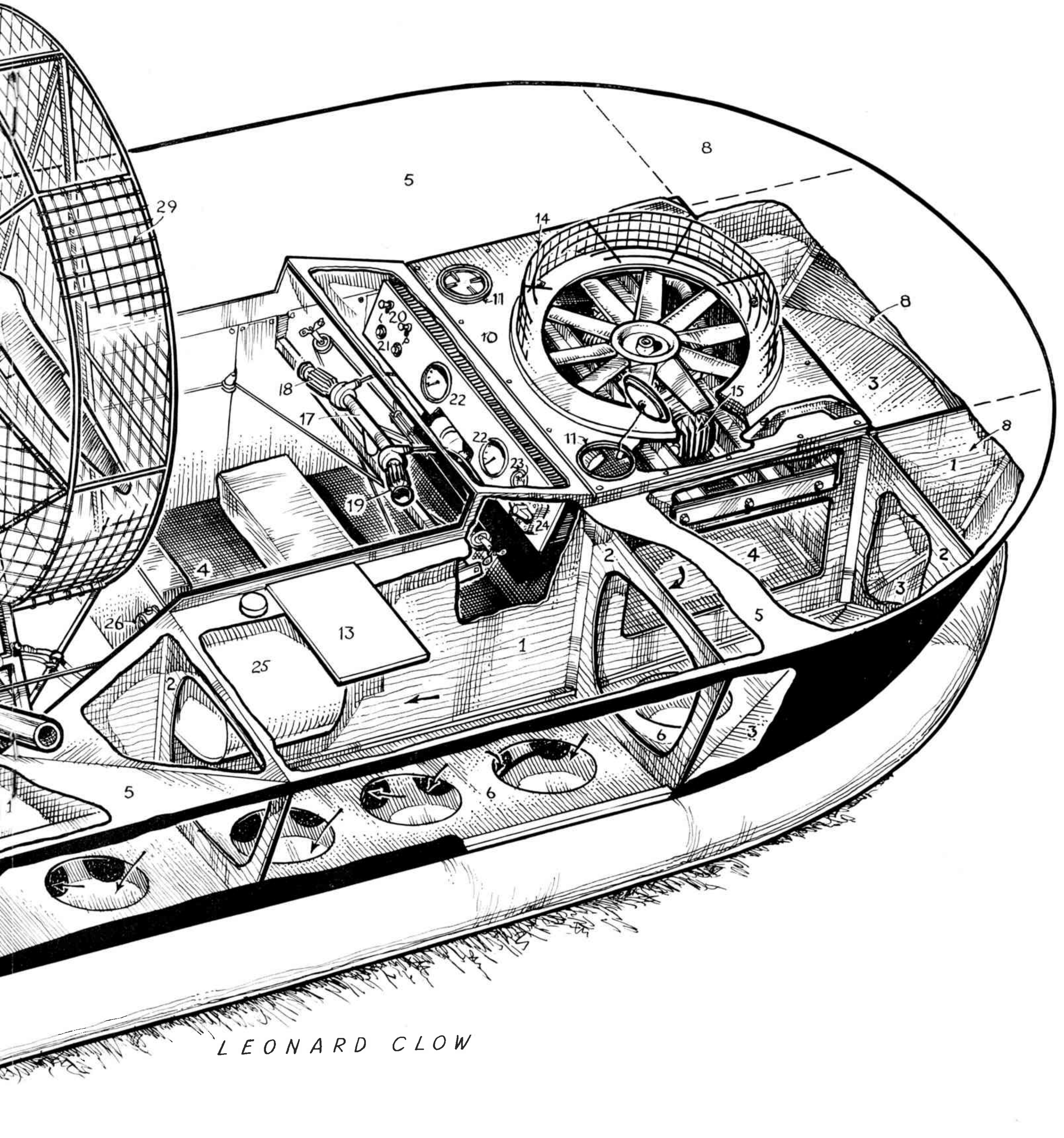
This drawing shows in detail the construction of a fingered bag skirt and the method used to fix it to the hull of the craft. Particular care should be taken when making and fixing the fingers. Note also how the main skirt is made in independent sections and then sealed together.

CUT-AWAY VIEW OF THE EXPRESS AIR RIDER



ANNOTATION KEY

1. Main former, ⅜ in. marine ply.
2. Side formers, ⅜ in. ply.
3. Anti-plough-in bow surfaces, ⅜ in. marine ply.
4. Engine compartment floor, cockpit floor, rear floatation box floor and rear deck, ⅜ in. marine ply.
5. Hull deck and sides, 2 mm. marine ply.
6. Hull air box floor, 2 mm. marine ply.
7. Rear floatation box.
8. Bow floatation boxes, filled with plastic foam.
9. Main former extends through rear decking, a rear engine mounting.
10. Lift engine hatch.
11. Engine spark plug and carburettor access hatch.
12. Hull inspection hatches.
13. Reinforced ⅜ in. marine ply step, with non-slip surface.
14. Lift fan guard.
15. Velocette Viceroy 250 c.c. 2-stroke engine driving "Multiwing" fan (electric starter).
16. Greeves 360 c.c. 2-stroke sports engine driving via four "V" belts, 4 ft. 6 in. Rollason propeller (electric starter).
17. Cycle type steering controls, cables to rudders.
18. Twistgrip throttle control for lift engine.
19. Twistgrip throttle control for propulsion engine.
20. Ignition switches, lift engine switch also controls electric fuel pump.
21. Starter pushes.
22. Engine Rev. counters.
23. Battery condition gauge.
24. Electrical Master switch.
25. Fuel tank.
26. Electrical fuel pump.
27. Securing rings (for transport).
28. Lift engine exhaust.
29. Crimped alloy wire propeller guard.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LEONARD CLOW

THE SKIRT

(continued from page 13)

lightweight material on the ground that being light and highly flexible it does not suffer so much from ground abrasions.

Being converts of the second school, we tried out a brand new material made by an Air Registration Board approved covered plastics firm. They are very much members of the lightweight material school and the material is no thicker than the average plastic mac. This material solved our biggest problem—stitching. In fact, the prospect of several thousand stitches being necessary was frightening.

We found we did not have to make one stitch, for this new material, which is a form of polyurethane-coated nylon, can be stuck together with a special adhesive.

The first stage in making a fingered bag skirt is to cut out the fingers. As they are spaced every three inches around the periphery of the craft that meant we had to make 132 fingers, plus a further 24 which we used for the stretch of skirt along the rear of the craft. By marrying two fingers together we turned the back row of fingers into cones. This prevents the fingers at the back from becoming miniature ploughs and scraping up any grit or hooking themselves on an obstacle.

We divided up the skirt into six separate lengths because it seemed the easiest way. Then we stitched them together later. We made up mitre boxes from card-board and plywood so that we got the corners just right. The fingers were stuck on in one swoop.

First, we put them in place—11½ inches down from the edge of the material, which leaves room for a fold—and secured them with Sellotape. Then when they were all in line we coated a half-inch wide strip along the skirt bag and the finger tops with the Tragacine adhesive. After the second coat the parts were pressed together.

Although they were quite secure after 48 hours it takes about a week for the bonding to "cure" to full strength. After that time, the bond is so good that the material itself will tear before the joint.

This also makes repairing the skirt an easy job. Damaged fingers can simply be cut off at the root and a replacement stuck in their place. Of course, for any emergency repairs the replacement fingers can simply be stapled in place. In fact an ordinary office stapling machine is a very useful item for it can also be used for rough repairs to thin plywood.

By calculating the volume flow and pressure produced by the lift fan, it is possible to work out the skirt pressure if you know the skirt area, cushion area and weight of the craft. Aim at having a skirt pressure between 2 and 5 lb. per square foot higher than cushion pressure.

There is a choice of method for trimming the skirt. Either do it with a slide rule or a pair of scissors, or both. The scissors-only method is the simplest and recommended by most professional hoverdynamicists. Simply cut out holes in the bag of the skirt every three inches. Start off with holes the size of a 10 new pence piece. Then hover up the craft and stand in the cockpit. Lean from side to side and if there is no give in the skirt, or very little, this indicates that bigger holes or more of them are necessary.

If the skirt has too much pressure in it the hoverheight will be poor but the stability will be very good. Simply repeat the process until the skirt gets softer—because more air is allowed to escape—but not too soft.

There is a happy medium where the skirt is not too soft and the hoverheight is at its best. By very gradually increasing the size or number of holes cut in the skirt this happy medium can be reached. If overdone, patch up some of the holes to increase skirt pressure. Push the craft over a row of bricks when it appears to have reached its best performance. If it goes over them without too much disturbance then all is well.

Although we did manage to operate with the fingered bag skirt, it gave problems. The fingers, especially on the corners, were difficult to adjust. As the diagram shows, unless they lie right the air loss is considerable. We tied them with string which curled and refused to uncurl properly. Then we used elastic bands as an experiment hoping the fingers would be self-adjusting, but this did not prove very satisfactory either. Eventually we found nylon cord which would not curl or coil up was the answer, but the job of tying on the fingers took many, many hours.

The second skirt we tried was a simple bag skirt, made the same way as the other but without fingers. And we chose this skirt simply because we needed one in a hurry. We decided to extend it forward to the front bows. And it was a great success although it took a tenth of the time to make.

On its first trial it took the craft round for the fastest lap of the day at the Hoverclub's Rally at Solihull.

On its second try out in the Hoverclub's Burton Constable Rally the craft was overall winner because of the perfect behaviour of this simple skirt over water. In fact over the land and water course the Express Air Rider covered the distance in 4 minutes, which was 2½ minutes faster than the runner-up.

But we are still persevering with a fingered skirt which is more efficient and more "slippery" but more difficult to produce.

Lift Fan

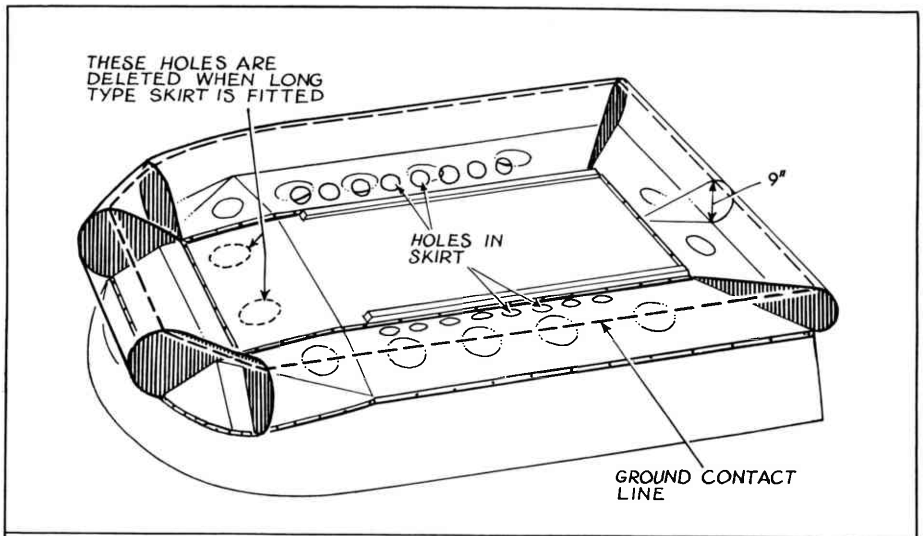
An industrial fan with nylon blades which are held together by a split hub was selected because the type is easy to match to any particular engine. If 12 blades put too much strain on the engine then you can remove four in a matter of minutes and try that. Also the blades come in varying degrees of pitch from about 15 degrees up to 45. The prototype uses 33 degree pitch. A new adjustable-pitch fan will be on the market shortly but this is likely to be more expensive. The makers are Airscrew-Weyroc of Weybridge.

The lift fan duct and cone is a job for the pottery class in the first instance. If they throw a mould for a small duct to fit around the fan, a glass-fibre skin can be laid by the handicraft class. They can also throw a cone to cover the fan hub and this too can be turned out in thin glass-fibre and clipped into place.

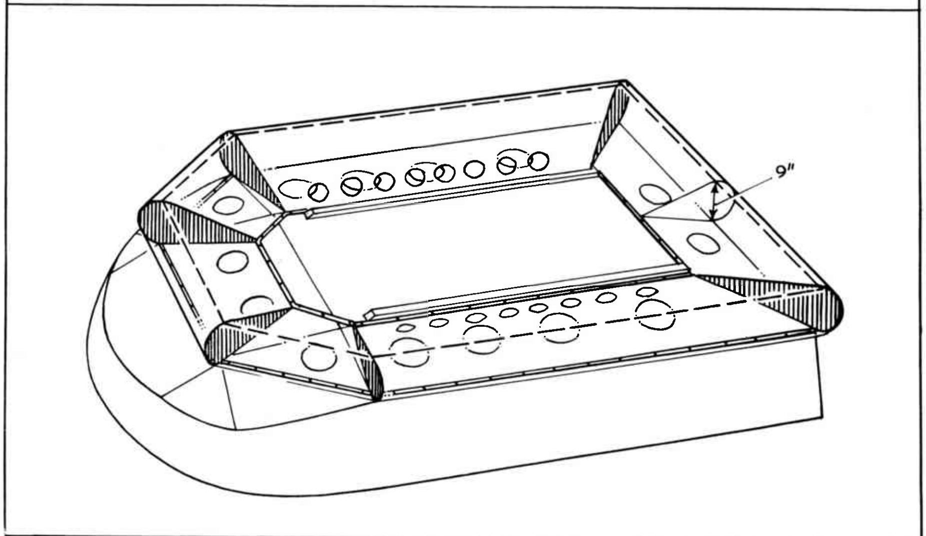
While they are at it, the potters could produce another cone for the front of the prop which could clamp to the flange on the propeller shaft.

Apart from the improvement in appearance, the efficiency of both fan and propeller would be slightly increased.

MAKING SIMPLE BAG SKIRTS



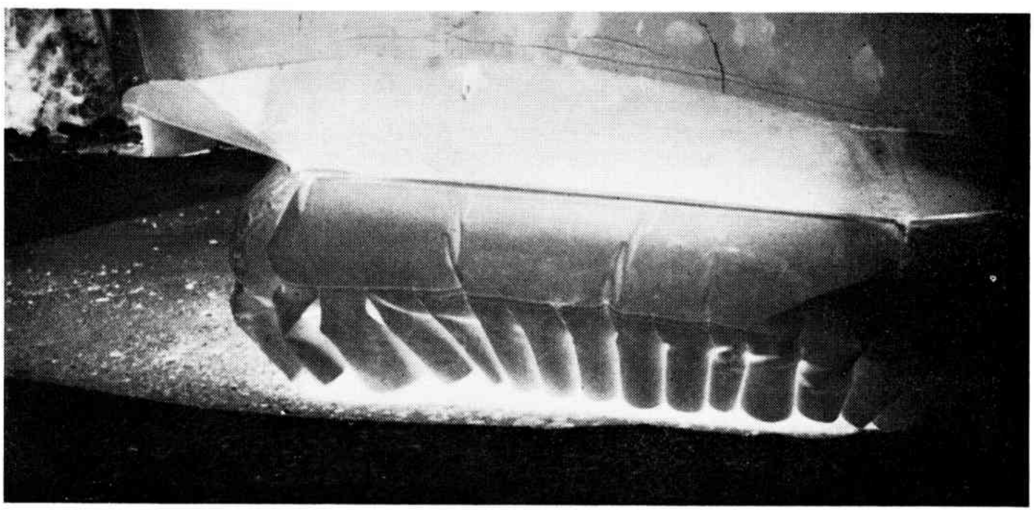
Long type skirt for craft having propulsion thrust centres 3 feet or more above ground level when hovering.

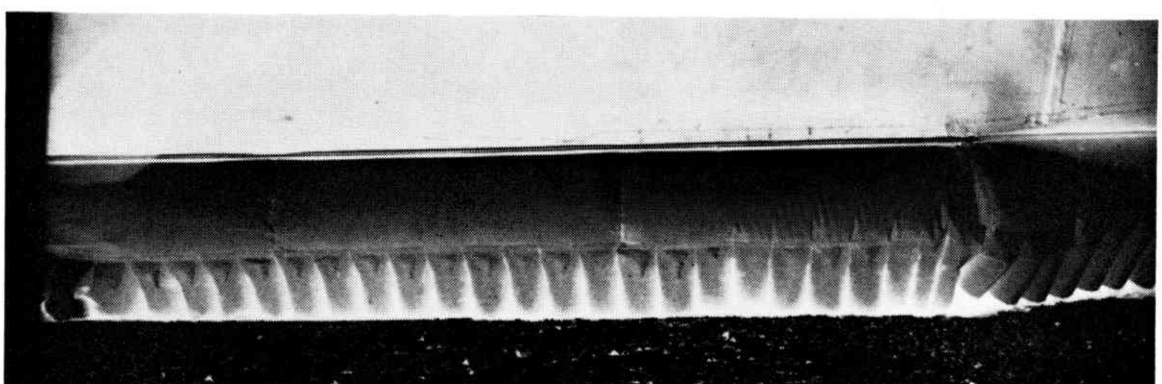


Normal type skirt for craft having propulsion thrust centres less than 3 feet above ground level when hovering.

SOME FINGERED SKIRT PROBLEMS

One of the time-consuming parts of fingered bag skirt construction is the job of trimming. These photographs, reversed for clarity, show how uneven fingers cause unnecessary air loss from the plenum chamber. Trimming the bow fingers is a major problem as can be seen from the picture on the right.





The side view of the craft, shown on the left, pinpoints the trouble spot found at the joint between side and bow skirt sections — between the seventh and eighth finger from the right.

FINISHING TOUCHES

Trimming the Craft

Ideally the craft should hover dead level. Thus to trim it all the items of variable weight should be as near the centre of balance as possible. The obvious variables are passengers and fuel tanks and they should be in or near the centre. If not then ballast is the only alternative and that means carrying extra weight.

Trimming the craft should be done when the hull is complete and the lift and thrust engines are in place. As the propulsion engine is further from the centre of the craft than the lift engine—and usually heavier—this means the batteries, fuel tank and any other moveable items will have to be forward of the centre of the craft. How far forward?—that is the next problem.

Certainly there is no problem fixing the batteries right in the nose of the craft. The fuel tank or tanks would have to go nearer the centre because of the different weight empty and full. This is another "trial and error" form of calculation. The fuel tank and electric pump can function with a long electrical lead or a lengthy flexible fuel pipe, so it can be moved into various positions to see which is best.

Of course, by weighing each item and measuring distance from the centre of balance it is possible to calculate on paper where the various components should go but it is up to the constructor to choose which method to use.

Painting

International Paints sent one of their marine paints experts to advise us. This firm have also prepared a paint kit for Express Air Rider builders which is available to schools and other educational authorities at two-thirds normal price.

First job is to seal the inside of the craft which can be done partly before the final outer skin is in position and the remainder after the hull is completed.

The kit gives sufficient paint to undercoat the whole craft and then a "Daily Express" blue final coat to the sides of the hull and the engine frames and a white deck top coat.

On the side of the hull, placed centrally, should be painted 'Express Air Rider' in white. The lettering is exactly as used on the masthead of the "Daily Express", so a useful guide is always readily available. This lettering —8 inches deep—appears on both sides of the hull. The inside of the cockpit can be painted or lined with a blue plastic coated foam padding to complete the livery..

Later, when the craft is surveyed the Hoverclub certification number can be painted on the bows.

The essential covering for the hull is a paint which does no more than form a waterproof seal. We used a metallic pink primer which is an aluminium based paint. Ideally three coats of primer should be applied, each one going on as soon as the previous one has dried. The first coat of this primer should be thinned down with ten per cent. of white spirit to make it soak into the timber.

If there are any hollows or cracks to fill this should be done AFTER the first coat of primer has been applied so that the stopping used is sandwiched between two waterproof skins.

When painting over glass-fibre rub down the resin with fine emery paper to get rid of any deposit and provide a grip for the paint. When rubbing down the ply do NOT use a fine emery paper as this merely rubs the fine sawdust back into the wood. A surface impregnated with loose dust does not give paint good adhesion.

Controls and Instruments

Firstly, list what is essential. There are two engines, so that means two throttle controls, two choke controls, two ignition switches. If the engines have self-starters that means two starter buttons.

The petrol pump also needs a switch and the petrol tank an on/off tap.

There must also be a master switch to cut off the complete electrical system in case of fire.

Only one instrument is essential—if coil ignition is used or self-starters fitted. Be it a simple ammeter, volt meter or a more pricey battery state indicator, the condition of the batteries at any time is worth knowing.

Rev. counters, air-speed indicators, oil temperature gauges, are all "optional extras". If engines are not running well it is best to use your ears and eyes. An experienced ear can tell engine performance as usefully as a rev. counter. Ignition lights and fuel gauges can be fitted—even trafficators if they bring happiness.

Points for your guidance . . .

Performance

Over water, which is more complex than travelling over relatively flat land, performance is dependent on these factors: The relationship between thrust from the propeller and aerodynamic drag with the air speed plus hydrodynamic drag which varies with both the type of skirt used and the actual surface condition of the water.

Over land the main considerations are changes in gradient, even small ones, and surface winds which have considerable effect simply because of the fairly low operation speeds of hovercraft as compared with aircraft.

These are no more than guides for the amateur to show that not one item alone, but a combination of many, must be considered when homebuilt craft do not perform as they might.

Lifting Power

One fact which amazes most people is the amount of lifting power possible from a comparitively tiny power unit. For example, a small paint spray compressor delivers enough air to feed an industrial hover pallet capable of skimming across a smooth floor with a load of more than four tons of machinery.

Another good example is the experimental hovercraft built by Royal Aircraft Establishment engineers at Cardington and named Krafty Kushion. Constructed mostly of inflatable dinghy fabric it has an old invalid carriage engine of 197 c.c. delivering about 11 b.h.p. for lift. And this is enough to lift seven men on its cushion with ease.

The newest 6 ft. by 4 ft. model produced at the British Hovercraft Corporation's experimental department weighs around 400 lb. The lift power comes from a moped engine of only 98 c.c.

Finding and Tuning The Right Engine...

If only two suitable engines are available there are no great decisions to be made. However, there are probably 143 motor-cycle experts who will give you a 143 different reasons why one engine is better than another. However confused you may become, remember the vital factor—power to weight ratio.

Like most other items of machinery if an engine is well above average the cost is usually well above average. High performance and high prices go very much together, simply because saving weight is always expensive. On racing cars and motor-cycles, aerospace and aircraft projects, weight saving can cost £100 to several hundred per pound weight saved.

Of course, this bears little relation to the amateur hovernaut's weight saving efforts. In practice, you will probably content yourself with finding a reasonably light engine with an alloy barrel and head in preference to one fitted with cast iron components. Also an engine with a removable gearbox can save over an engine with an integrated unit which cannot be separated. Two-strokes are popular because they usually have less working parts than four-strokes and thus weigh less. If a two and a four-stroke are used together then two petrol tanks are needed—one for petrol and the other for petrol/oil.

The two most commonly used engines for small hovercraft are the small Villiers—the type that are used in invalid carriages—the older models of Bond minicars and the small Velocette scooter twin. Many a hovercraft is powered by a couple of old Villiers cut from an invalid carriage in a car breaker's yard and costing a fiver apiece.

They are adequate engines but they do not have exceptionally high performance compared with the Greeves Challenger engines which give more than 33 brake horse power from a single 360 c.c. cylinder. For those who prefer the smoother running four strokes, the Triumph 500 or 650 is one of the best available in quantity. It is a fairly heavy unit but its power to weight ratio is what must be considered.

Even water-cooled car engines should not be dismissed because of their weight. Normally a car engine is more reliable than the average motor-cycle engine, another worthwhile factor to consider. One or two light hovercraft are already using Hillman Imp engines for both lift and thrust, taking the lift drive from one axle and the thrust from the other. The old Austin Seven engine that has been rebuilt for the Reliant three-wheeler is also worth considering. There is one Express Air Rider, built by Forde Park School in Devon with a Morris 1000 c.c. engine for thrust and it works well.

Tuning the Engine

There are many ways of improving the performance of an engine, sometimes by up to 25 per cent. Such work is best carried out by an engine tuning specialist. Even with the simpler jobs such as cleaning up exhaust ports, polishing up and shaving cylinder heads (to increase compression ratio) fitting up filtration and exhaust systems, expert advice is essential.

Of course, an engine's performance can often be increased by 25 per cent. simply by adjusting the carburettor properly. In adjusting the fuel supply one point which is often forgotten is that a motor-cycle engine usually has a gravity feed tank whereas in light hovercraft, where the importance of a low centre of gravity is paramount, tanks are set low and the fuel is pumped by electric petrol pumps. The difference between gravity feed and forced pump feed is often so great that a completely different set of jets and needle are required to ensure that the carburettor functions satisfactorily.

For That Something Extra

Only if you are prepared to go to a great deal of effort and expense should you switch from petrol to an alcohol fuel such as methanol. There is no doubt that running an engine on "dope" improves performance considerably. But there is a lot of work involved in the conversion and once made there is always the job of ensuring you have sufficient supplies of the special fuel on hand.

If the conversion is thought worthwhile, then stick to methanol or some lightly "doctored" variant. Leave the exotic and hazardous nitro-methanol cocktails to the professionals. Some of these elaborate dope cocktails are so "touchy" they cannot be transported by car and have to be mixed on site.

Expert help in making the conversion is advised. The essential rule is to make sure that the engine is never,

(continued overleaf)

The prototype gets an engine test from Chief School Projects Advisor, Mr. L. Warren, at Ramsden School, Orpington, Kent, where this craft was built. Instructing is Mr. Gordon Handley, the school's Head of Technical Studies.

Engine Tuning

(continued from previous page)

ever, starved of fuel when it is running. If it is, the results can be disastrous and the engine will be ruined in five seconds flat!

To ensure an adequate supply means using big fuel pipes, big taps—at least $\frac{1}{4}$ inch size for safety—and big jets. Methanol jets are not produced in quantity so ordinary petrol jets are usually drilled out. Methanol has a high cooling property and it is for this reason it has to flow through the engine in comparatively large quantities. Without such a supply the engine simply burns out. When used in two-strokes, methanol has to be mixed with a castor-based oil. Ordinary motor oil is useless because it just will not mix.

Another point to watch is that petrol does not mix with methanol so any items such as tank, pipes and carburettor which have been used with petrol, require thorough cleaning. Supply problems do crop up from time to time and very, very few garages keep any stocks of methanol. At fuel specialists it costs between 14s. and 18s. per gallon and the castor-based oil is also more costly. These are items worth considering before making the conversion.

And a final warning: If you do use methanol, make sure none of your friends' cars are near the exhaust pipes when you run up the engines, for you will lose them—your friends, that is—methanol exhaust fumes can demolish paintwork from several yards!

WHAT NOW?

One thing is certain, the more the craft is used the more ways it can be improved will become obvious. The basic hull is an ideal testbed for trying out "pet" theories. There are a host of modifications that can be carried out on everything from propulsion units to skirt design. After all, the wheel has been around for countless thousands of years and it is still being modified one way or another!

A big lift engine could be fitted to produce enough air not only to supply the air cushion but also provide forward propulsion through low pressure air jets in the rear of the craft. Or perhaps the lift engine could be used just for the air cushion and side puff ports to give directional control. Two holes can easily be cut in the side, hinged flaps fitted and operated by a cord or cable so that they can be sealed when not in use, and that is all there is to puff ports.

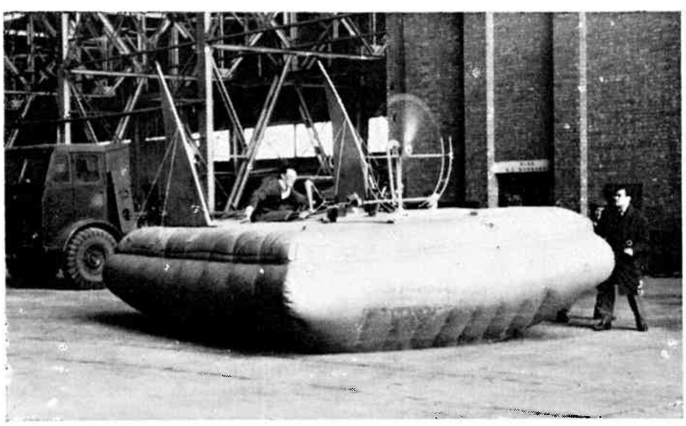
Simple plywood shutters can be fitted almost anywhere to divert more air to one side than the other and provide the essentials for a banking system to be used when cornering. And how about a braking system—again using a shutter? First seal off a few of the holes in the skirt which feed the plenum chamber. This will starve the plenum chamber of the necessary air so the craft will "stick" to the surface. Now cut a 12 inch circular hole in the floor of the craft under the lift engine which will then compensate for the air restriction in the skirt feed. Fit a sliding shutter over this aperture and control it from the cab.

To slow down the craft, all you do is close this shutter and the craft will slither to a halt on the cushion. Over grass there will be little skirt wear using this method of stopping. Its advantage over the normal method of simply decaying the cushion until the craft comes down on its hard structure or skids is that the craft is always on an even keel. With the normal way the front of the cushion might decay first and the front dig in and cause an accident. It is also a more dignified way of stopping on water!

The variations of skirt design are virtually unlimited. It could be anything from a curtain of tubes linked together or free standing, to a mass of separate hover pads, each a complete air cushion in itself. And nearly all of these can be fitted to the Express Air Rider hull for that is one of the reasons it was so designed.

For thrust, a ducted fan could be fitted or even a flexible spoked wheel with paddle blades for over water travel. The possibilities are unlimited.

The professionals have made tremendous advances in hovercraft technology but they have just broken the surface of this amazing new science. A few years ago, hovercraft skirts had a total lifespan of two hours. Now after 2,000 hours running they are still useable. But that is still not good enough. New ideas and time to experiment are often neglected by the professionals because they have so many other research projects in hand. That is why the amateur, schoolboy or adult, could be first to come up with some of the answers before the professionals.



The massive air cushion that a small 197 c.c. engine can produce. This craft has lifted seven adults.

MORE IDEAS

To illustrate the many possible variations for which the basic hull is suitable, the specifications of the craft built by Forde Park School, Newton Abbot, Devon are listed. They not only provide a good example of what can be done but are a further source of ideas.

HULL

Built of $\frac{7}{8}$ in. square and $\frac{3}{4}$ in. square spruce stringers—all plywood marine-ply. All ply joints scarfed 1 in 10: All joints secured with Aerolite glue: Corner joints reinforced with $1\frac{1}{2}$ in. glass-fibre and resin. Main beams built of 6 mm. ply. Decking 6 mm. ply. Floor—two sheets of 6 mm. ply, sandwiching $\frac{3}{4}$ in. square grid at 5 in. centres, spaces filled in with $\frac{3}{4}$ in. thick Polystyrene. Sides of hull 4 mm. ply.

SKIRT

Made from Polyurethene coated nylon as one bag, with holes for lubrication and fed from duct under lift fan. Skirt is 4 in. higher at front of craft than rear. Secured to craft by chromium-plated brass screws running through $\frac{1}{2}$ in. by $\frac{1}{4}$ in. beech beading. Skirt constructed with "Bostik C", plus stitching. Seams reinforced with strips of same material.

LIFT ENGINE

Bella Zundapp 200 c.c. Two-stroke horizontally mounted. Transmission—direct to 10-bladed plastic fan through flexible coupling. Engine and fan unit is easily retractable from hull. Glass-fibre cowling reinforced with $\frac{1}{4}$ in. mild steel bar. Safety guard on lift fan made from 3/16 in. mild steel rod, located on four mountings lopped in with Nettlefolds locking nuts.

THRUST ENGINE

Morris 1000 c.c. O.H.V. mounted in $\frac{3}{4}$ in. square hollow section tube. Transmission to 31 in. nylon propeller from engine flywheel by double 'A' section V-belt pulleys to same on propeller. Ration of drive 1 : 1.

Propshaft mounted in double roller bearings using Commer half-shaft and bearings. Prop secured to half-shaft by one $\frac{7}{8}$ in. shaft running through centre, locked by 7/16 in. B.S.F. H.T. bolt, together with two 5/16 in. B.S.F. H.T. bolts onto boss.

ENGINE MOUNTINGS

Adjustable track, moveable forward and reverse by 2 in. distances. Engine secured to track by 7/16 in. B.S.F. H.T. bolts.

FAN GUARD

Fabricated from 10 gauge aluminium, supported by $\frac{3}{4}$ in. by $\frac{1}{8}$ in. mild steel flats and pop riveted together. Front guard made from $\frac{1}{8}$ in. galvanised wire mesh, supported by $\frac{1}{2}$ in. by $\frac{1}{8}$ in. mild steel flat struts.

RUDDERS

Made from 9 mm. marine ply and operated by plastic coated shroud wire running through $\frac{1}{2}$ in. inside diameter conduit tube to steering wheel running on double aluminium pulley. Cables are adjustable.

FUEL TANKS

Situated within easy reach of shut off, lift motor fuel situated in a tank placed on the port side of upper decking. Thrust fuel tank situated on top of propeller cowling.

CONTROLS

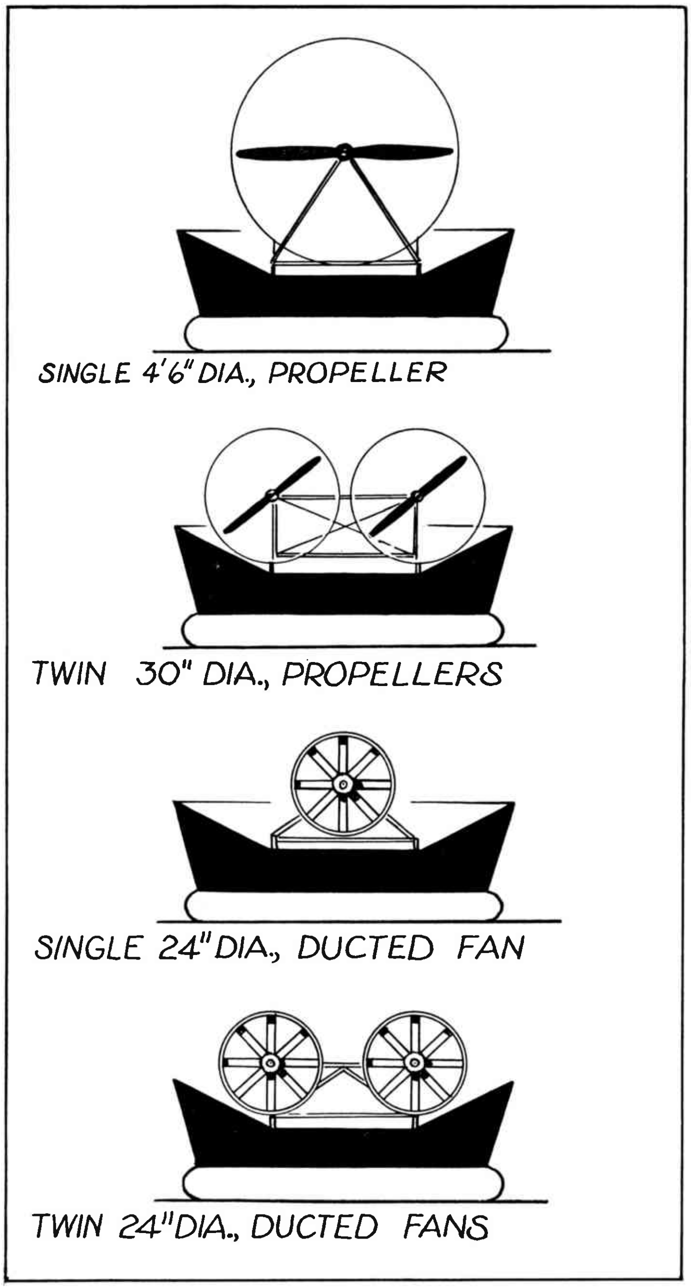
Rudders by steering wheel. Two ignition solenoids and two ignition switches, two throttle controls and two choke controls.

WINDSCREEN

One Renault Dauphine triple toughened rubber mounted rear car window, supported by fabricated brackets on to deck.

IGNITION

Through coils from two 12-volt car batteries, charging unit from lift engine.



Some of the possible layouts for thrust systems. On this craft the control system is little affected by the selection of one or two propellers.

HOW TO HOVER

READ THIS PAGE THREE TIMES BEFORE YOU TRY THE CONTROLS

It takes an average of eight hours to teach a pupil pilot to take off and land a light aircraft unaided. It takes about the same time to teach the average person to drive a car competently. With light hovercraft it is a case of self tuition, but most people will manage reasonably good control within four hours.

The most important point to remember is that once the cushion is inflated and the thrust engine is turning the propeller, things happen fairly quickly. These things can be either controlled, unpleasant or downright painful.

So Stage One is to manhandle the craft to the middle of a fairly flat piece of ground, preferably grassland with no immoveable objects around. Then when any audience you collect is clear, start the lift motor and throttle up. Just sit there moving the lift throttle up and back until you get the feel of the air cushion.

Note the time it takes for the cushion to decay (deflate) after you have closed the throttle. This time lag is important. Depending on the engine used, it may be quicker to cut the lift engine by switching off the ignition switch.

The time lag lets you know just how long it will take to make an emergency stop, by dropping the craft on its skids. Also, the time of an emergency stop—and the distance travelled before the craft comes to rest—is dependent on the surface over which it is travelling. Over a very smooth tarmac the craft might skid for 25 yards. Over short cut grass it may go further. It depends on the adhesion of the skids.

The kindest way to stop a light hovercraft is to do a twissle turn (go through 180 degrees) so that the opposing thrust overcomes the momentum. This keeps the skirt and skids from grinding along the ground. It takes considerable practice. But do not attempt emergency or twissle stops until you feel confident.

Still using only the lift motor, lean to one side and note what happens. The craft will edge sideways because of the uneven skirt. Next more kinesthetics. Lean forward and as the nose drops the craft will edge forward, again because of the blast of air escaping from the section of raised skirt. Practice moving the craft forwards, sideways and diagonally by this method.

Then start the thrust engine making sure there is nothing loose around the propeller . . . and do not wear a tie or a long scarf like you see in "Keystone kops" type movies.

Use a low thrust engine throttle setting and once you are moving at say ten miles an hour put on full rudder and gauge the turning circle you can achieve. Try the other rudder and then continue the exercise, gradually increasing throttle setting and speed.

Next practice on some ground which has an incline and note how the craft behaves. Take a run at the incline—with a long enough run you can go up a 1 in 10 incline—and let the craft silde backwards. If you get to the top then come down backwards. Only if you have sufficient space do you attempt to come down nose first with thrust engine going.

Avoid sliding down sideways until you really get the "feel" of the craft. Always remember hovercraft are like rivers—they flow to the lowest point of the ground.

Another good exercise is to use full rudder, and full thrust power and spin the craft. The "G" force can be surprising. Your effective weight can increase two or three fold. Hold an object in your hand and feel it becoming "heavier" as the spin increases. Basically what you are acquiring is the "feel" of the craft which cannot be taught any other way.

Before you attempt to run over water make sure you wear a life jacket. Better to be a living sissy than a nonchalant corpse. Try it on a small shallow lake where there is a very smooth approach from land to water. Keep it dead straight.

Do not try any fancy turns until you have made several straight runs. Another good place to try a craft is along a fairly flat beach where you can describe a very gradual half-moon over a 100-yard run. Remember choppy water is something you do not tackle until you have considerable experience.

If you come back through your own wake on a small lake then cut the wake at an angle of 45 degrees. Even the big hovercraft do this because it is simply the least disturbing way.

At slow speeds over water the craft acts very much like a boat but at speeds in excess of about 12 knots the craft gets "over the hump" and becomes a hydroplane. You just float across the surface of the water and as there is no drag, speeds beyond 30 knots are quite practicable. However again, do not try fast runs until you have spent at least two hours on the water getting the "feel" of the craft.

Over snow the craft behaves much as if over a solid surface. Wet sand or dry sand does not cause any problems, but wear goggles. The time it takes to get sand out of your eyes may take just a few seconds too long. . . .

Using the craft at speed—and speeds over 50 miles per hour on land are possible—should only be done when weather and ground conditions are right. Wear a crash helmet just in case.

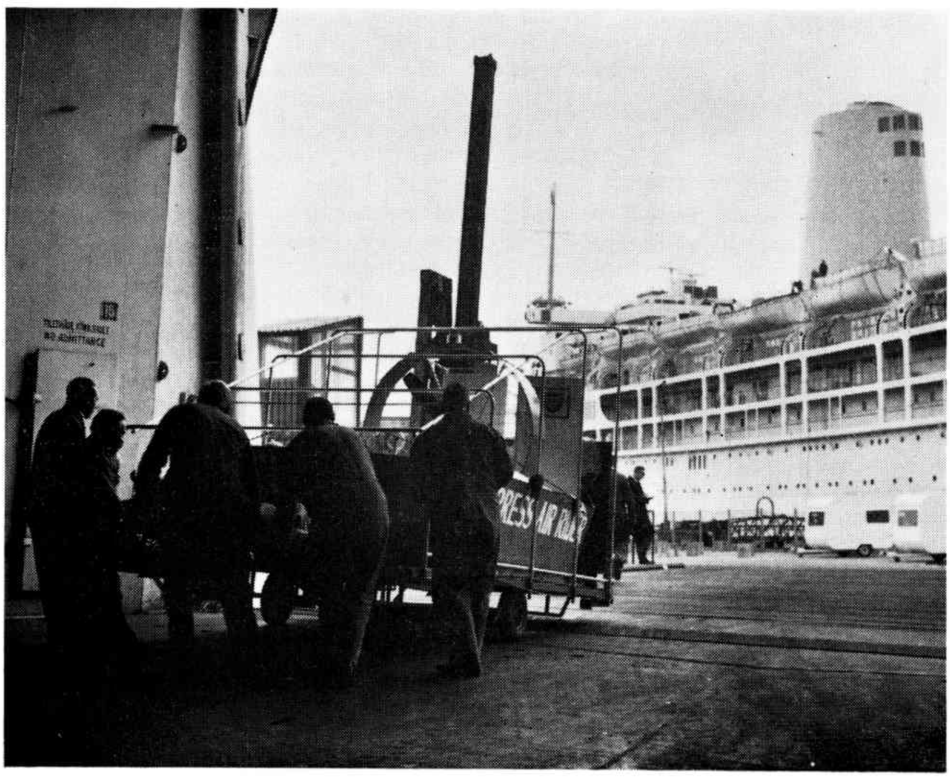
But the most important thing to learn is that you must take care at all times that there is absolutely no chance of any bystander being injured should you get out of control.

and when you can hover . . .

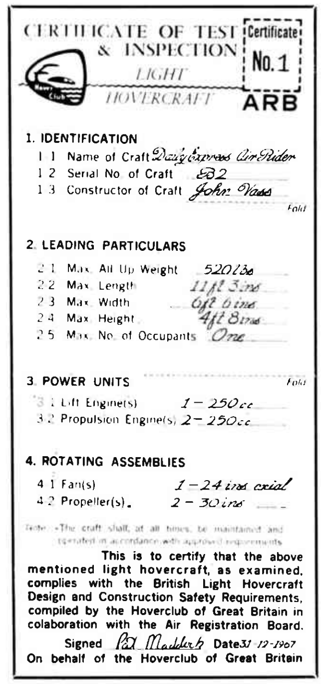
. . . you can go rallying

and maybe win a competition

The Express Air Rider on its way (above) to the overall and class wins at the Hoverclub's Burton Constable rally. It is pictured on the water section where John Vass had the craft at 30 knots. On the right is pictured the finalists in the first ever inter-schools hovercraft contest held in September 1968 taking their craft aboard the Swedish ferry for their prize trip. More than 170 British schools entered the competition devised to find out which school could build the best Express Air Rider two-seater, a craft designed specifically for school project work. Although many retired before the final judging, some very smart craft from schools as far apart as Devon and Lancashire competed for three trophies presented by the contest's sponsors British Petroleum. The winning team—Rossall School, Fleetwood, Lancashire — earned themselves a bonus prize of a 10-day trip to Sweden where their craft was the centre-piece of the Stockholm Teenage Fair. Now a contest for Swedish schools is being planned, Australian scouts are planning an inter-district contest and so it goes on.



Safety and the Regulations



CERTIFICATE OF TEST & INSPECTION
LIGHT HOVERCRAFT
Certificate No. 1
ARB

1. IDENTIFICATION
1.1 Name of Craft Daily Express Air Rider
1.2 Serial No. of Craft EB2
1.3 Constructor of Craft John Vass

Fold

2. LEADING PARTICULARS
2.1 Max. All Up Weight 520 lbs
2.2 Max. Length 11 ft 3 ins
2.3 Max. Width 6 ft 6 ins
2.4 Max. Height 4 ft 8 ins
2.5 Max. No. of Occupants One

3. POWER UNITS

Fold

3.1 Lift Engine(s) 1 – 250 cc
3.2 Propulsion Engine(s) 2 – 250 cc

4. ROTATING ASSEMBLIES
4.1 Fan(s) 1 – 24 ins axial
4.2 Propeller(s). 2 – 30 ins

Note.—The craft shall, at all times, be maintained and operated in accordance with approved requirements.

This is to certify that the above mentioned light hovercraft, as examined, complies with the British Light Hovercraft Design and Construction Safety Requirements, compiled by the Hoverclub of Great Britain in colaboration with the Air Registration Board.

Signed Pat Maddock Date 31-12-1967
On behalf of the Hoverclub of Great Britain

(Above) Mr. J. P. W. Mallalieu, Minister of State at the Board of Trade (left), talking to John Vass when he visited the Express Air Rider stand at the 1968 Boat Show to present the first Certificate of Test and Inspection (right). The certificate carries the signature of Mrs. Pat Maddock, Secretary of the Hover Club of Great Britain Ltd., to whom the Board of Trade are delegating responsibility for the control of light hovercraft.

All light hovercraft are shortly to be controlled by a certificating authority which means that they will require a Certificate of Test and Inspection. Already, the first certificate has been granted to the original Express Air Rider.

Before craft are officially surveyed there are certain tests that the constructor should carry out. The structure has to have adequate strength to withstand all internal and external loads in the most adverse operating conditions. Thus the first test is to load it to double its design maximum weight, distributing the load evenly.

Once it has been established that the workmanship is sound, check the layout so that if any attachments break loose—say in a crash—they will not cause injury to the occupants of the craft. In fact, the attachments should be so secure that they withstand inertia forces of the magnitude of 6g.

Rotating assemblies are the real hazard, so the greatest care must be taken. This includes everything from drive belts to propellers and fans.

All rotating assemblies, except of course the engines, should withstand being run at $1\frac{1}{2}$ times their maximum design speed. The integrity of rotating assemblies should be such that they will withstand being run at this speed both under conditions of no acceleration and under those conditions of acceleration and gyroscopic loading which the craft can reasonably be expected to encounter during operation (assume angular accelerations of .5 radian/sec.).

Propellers must be constantly checked throughout their working life. And if there is the slightest doubt about the ability of any other rotating assembly to comply with the regulations, not only on test, but also under prolonged use over a period of time, then it must be contained by the surrounding parts of the craft. The risk of injury or damage to the crew or spectators must be reduced as far as is practicable.

Again, the regulations stress the risk of rotating parts and say that all rotating assemblies must be guarded in such a way that it is not possible for any part of a person to accidently touch the space swept by the rotating assemblies when they are rotating.

The rigidity of these guards shall be such that they will withstand any pressure that may reasonably be expected to be applied to them without themselves touching the space swept by the rotating assembly that they are guarding.

The No. 1 fire risks are the fuel tank and supply lines. These must be constructed and mounted so as to prevent damage in the event of a crash. Leaks, due to vibration or distortion in the craft's structure during operations should also be avoided, if possible.

Fuel tanks and supply lines should be so located that in the event of a leak occurring the escaping fuel is prevented, so far as is possible, from reaching any hot parts of the engine or exhaust system or electrical parts.

It should also be possible for the driver of a craft when in his seat and strapped in when a harness is provided, to cut off the supply of fuel to the engines and electrical systems.

Under the regulations all craft must have a fire extinguisher suitable for dealing with petrol fires which is readily accessible from inside or outside the craft. The engine covers and fuel tank covers should give easy access for fire fighting.

Buoyancy is also covered in the regulations and craft intended for use over water must have a minimum buoyancy of 150 per cent. of their maximum all up weight, the buoyancy being so located on the craft as to provide adequate stability when the craft is water-borne.

INSURANCE

The Hoverclub have arranged a special policy for amateurs—details from Hoverclub.

School and youth organisation hovercraft policies are available from Green Street (Insurance) Ltd., Insurance Brokers, 125 Felstead Road, Orpington, Kent. Telephone: Orpington 22857.

Many insurance companies will frame individual policies covering all the needs of amateurs.

THE HOVER CLUB OF GREAT BRITAIN LTD

The Hover Club of Great Britain is recognised as the governing body for all light hovercraft—that is one or two-seater craft below 2,000 lb. in weight with a total horse-power of not more than 80 and used only for recreational purposes. All other hovercraft will come under the Hovercraft Bill. But the club will not only govern but continue to assist the amateurs with their problems, organise rallies all over the country and generally promote the new sport of hoverplaning.

Headquarters—Secretary: Mrs. P. Maddock. Offices: 12 Lind Street, Ryde, Isle of Wight.

BRANCHES

Army Hover Club—Chairman: Lt.-Colonel E. Barsley, H.Q. Maritime Wing, Army School of Transport, Southampton. Secretary: S.-Sgt. K. Anderson, Army Apprentices College, Arborfield, Berks.

Chilterns Hover Club—Chairman: Mr. R. A. Shaw, Cobbs, Felden, Hemel Hempstead. Secretary: Mr. J. Kinross, The Hollies, Weedon, Aylesbury.

Dee and Merseyside Hover Club—Chairman: Mr. M. J. Turner, 29 Kingsley Avenue, Eastham, Wirral, Cheshire. Secretary: Miss J. Kincaid, 18 Queensdale Road, Mossley Hill, Liverpool, 18.

East Anglia Hover Club—Chairman: R. G. Taylor, 14 Broadstairs Road, Lowestoft. Secretary: Mr. S. Basten, 31 Valley Road, Tasburgh, Norwich.

Grantham Hover Club—Chairman: Mr. C. Blankley, Gem Luxury Coaches, Colsterworth, Lincs. Secretary: Mrs. C. Blankley (as above).

Isle of Wight Hover Club—Chairman: Mr. C. E. Smith, 71 Monkton Street, Ryde, Isle of Wight. Secretary: Miss D. M. Jackman, 53 St. David's Road, East Cowes.

London Hover Club—Chairman: Mr. J. Vass, Rosehaugh Farm, Newbarn Lane, Cudham, Kent. Secretary: Mr. K. Oakley, 128 Robinson Road, Tooting, London, S.W.17.

Midland Hover Club—Chairman: Mr. C. Clark, 24 Uppingham Road, Leicester. Secretary: Mr. D. Waters, Dept. of Transport Technology, University of Technology, Loughborough.

Manchester Hover Club—Chairman: Mr. D. Johnson, 18 Lawson Avenue, Gatley. Secretary: Mrs. P. Rowbottom, 56 Weldon Road, Altrincham.

North Eastern Hover Club—Chairman (vacant). Secretary: Mr. J. Morgan, 114 Birchinton Avenue, South Shields.

Road Research Laboratory Hover Club—Chairman (vacant). Secretary: Mr. A. Carson, R.R. Laboratory, Crowthorne, Berks.

Scottish Hover Club—Secretary: Flt. Lt. D. Gurney, Officers Mess, R.A.F. Leuchars, Fife.

Sussex Hover Club—Chairman: Mr. R. Morgan, 14 The Towers, Grand Avenue, Worthing. Secretary: Mr. K. Wheatley, c/o Caftyns Garage, Seaside Road, Eastbourne.

FEDERATION

International Federation of Hoverclubs. Secretary: Mrs. P. Maddock.

AFFILIATED CLUBS

National Association of Air Cushion Vehicle Enthusiasts, U.S.A. Secretary: Mr. Jan Eglen.

Trinidad and Tobago Hover Club. Secretary: Mr. Nigel Seale.

Hover Club of Canada. Secretary: Mrs. Iris Hicks.

Hover Club of Finland. Organiser: Mr. Eero Martikainen.

Hover Club of Majorca. Organiser: Mr. Benito Roth.

Hover Club of South Africa. Secretary: Commander J. F. Kerr.

Rupublica Argentina Hoverclub. Secretary: Capt. J. Cheek.

Club Français des Aeroglisseurs, Paris. Organiser: Mr. J. Beaudiequin.

Further details on the above clubs are available from the Hoverclub of Great Britain.

If You Want to Know More . . .

PUBLICATIONS

Hovercraft World, published 8 times a year (2s. 0d.) or £1 0s. 0d. for 8 issues, inc. postage. Published by Air Age Publications, 1 Temple Chambers, Temple Avenue, London, E.C.4.

Air Cushion Vehicles, (2s. 6d.) monthly. Published by Iliffe Transport Publications, Dorset House, Stamford Street, London, S.E.1.

Hovering Craft & Hydrofoil, 12 issues annually (7 gns). Produced by Kalerghi Publications, 50-52 Blandford Street, London, W.1.

Hover Club News International. Published by the Hover Club of Great Britain and issued to members.

REFERENCE BOOKS

Hovercraft Design & Construction, by Elsey & Devereau, Published by David and Charles.

Jane's Surface Skimmer Systems, edited by Roy McLeavy. Published by Sampson, Low, Marston & Co.

Helicopter and Hovercraft Design, by Basil Arkell. Published by Weidenfeld and Nicolson.

Homebuilt Hovercraft, edited by G. H. Williams. Published by Iliffe Transport Publications.

History of Air Cushion Vehicles, by Leslie Hayward. Published by Kalerghi Publications.

CONSULTANTS

B. H. Arkell & Company (Engineers), 1 Temple Chambers, Temple Avenue, London, E.C.4.

Hoverprojects Ltd., The Bowring Building, Tower Place, London, E.C.3.

Getting The Parts

The main suppliers of hovercraft components for the amateur constructor have been Britain's scrap yards. Parts salvaged from invalid carriages to items made for the TSR-2 have found their way into amateur hovercraft. In fact it is only recently that many firms have realised the potential market value of this rapidly growing sport. There are still a large number of firms who are just not interested in adapting or, indeed, supplying their products for light hovercraft. One of Britain's biggest motor-cycle manufacturers unfortunately comes into this category.

However, at its present rate of growth there will be several thousand light craft in Britain within the next five years, thus creating a demand which even the big firms cannot ignore. Several new companies to meet the needs of the amateur hovernaut have been formed and several well established firms are now showing a special interest in this new sport.