Turnover Structures

By Kirk Ulman, EAA 10938
1604 Coronado Dr., Champaign, Ill.

CIVIL AIR REGULATIONS state that the structure of an aircraft shall be designed to protect occupants from injury in event of a turnover unless the design of the aircraft generally precludes turning over. Most of us will interpret this to mean that an airplane with a conventional landing gear should have an overturn structure.

Biplanes and high-wing airplanes generally have inherent overturn protection; therefore, we will consider low and mid-wing ships. Many of the aircraft displayed at Rockford in August had no visible turnover protection. Some of the well built little ships had a half-hearted looking affair that looked as if it had been added as an after-thought.

Crash helmets and shoulder harnesses are fine, but they will not keep an airplane from coming down on a pilot and breaking his neck. There are few of us who have not seen a lightplane on its back. Most of the overturned ships have been high-wing jobs where the occupants have been suitably protected, but remember the damage the airplane sustained from a rather easy turnover: buckled struts, broken windshield, bent tubes, and a cowling smashed flat against the engine. Remember especially the buckled struts. Those struts were designed to take quite a negative flight load without buckling.

The old P-26 had an enormously high headrest. The first few models had normal size headrests; but pilots were killed when the ships turned over, and the huge headrest had to be provided for protection. This shows the fallacy in most cases of a turnover structure just an inch or two higher than the pilot's head located behind the cockpit.

Figs. 1 and 2 depict an airplane of size and proportion similar to the typical homebuilt airplane. In Fig. 1 the turnover structure is shown located behind the cockpit. Notice that the top of the pilot's head is actually below the ground line. This is protection? In most cases a turnover structure behind the cockpit will have to be very high and heavy to do any real good.

Fig. 2 shows the airplane with a turnover pylon of same height located ahead of the pilot. Note the distance afforded between the pilot's head and the ground. Even though a turnover structure is located ahead of the cockpit, it is desirable in many cases to have it slightly aft of the center of gravity as shown in Fig. 2 so that the normal inverted resting position will allow more room for exit between the airplane and the ground. If the aircraft momentarily rocked back on the tail when turning over and the fin were to be smashed to nearly one-half its original height, we can visualize the clearance afforded by projecting a line from the top of the turnover structure to this height point on the tail (X mark). We can do this to the airplane in Fig. 2 and see that there is still pilot protection.

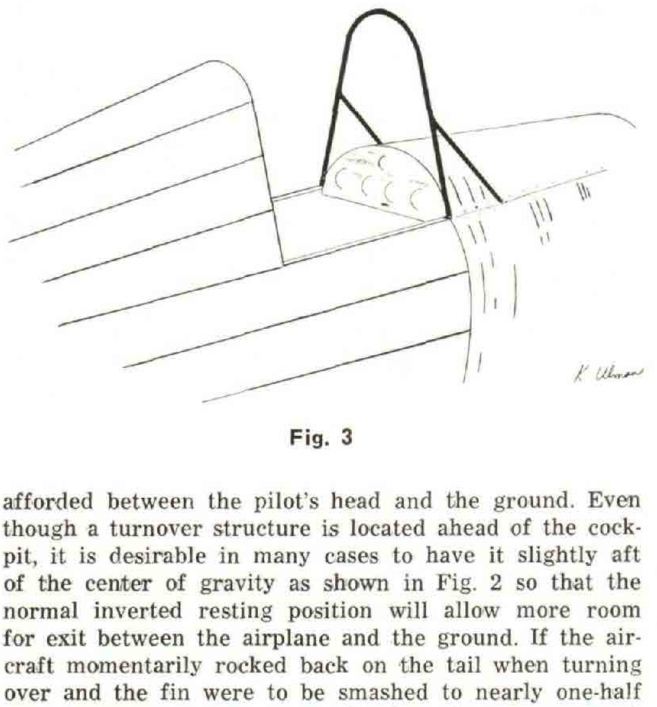

Fig. 3

On an existing airplane turnover protection can be determined by laying a board or length of electrical conduit on top of the airplane from the engine to the highest piece of solid structure. Don't deceive yourself either, as a flimsy windshield frame isn't solid structure. A piece of string stretched from the engine to the highest piece of solid structure will also do. The important thing is to make sure the pilot's head does not protrude above this projected line.

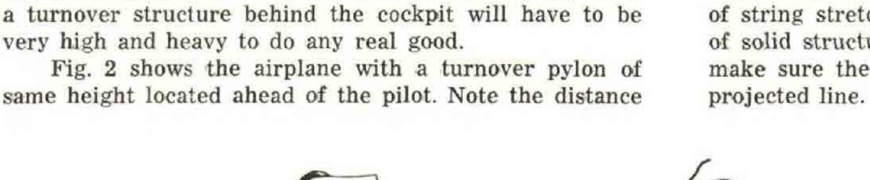

Fig. 1

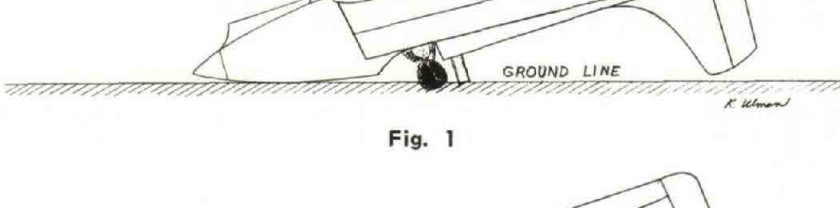

Fig. 2

Once we have determined where the turnover structure should be located, we are faced with the slightly more vexing problem of how strong to make it. The conditions of the turnover greatly affect the impact force on the cockpit area, and the configuration of the aircraft is also a factor. It would be ridiculous to try to stress the structure to withstand the impact force of a dead stop turnover at 70 mph. The high translational velocity becomes a rotational velocity which diminshes to zero in a very short time at ground contact. Fortunately, the chances of a dead stop, high speed turnover are remote as the aircraft will generally slide on its back or tumble again; and in so doing will dissipate energy more gradually. The seat belt helps us determine the necessary strength of the turnover structure. Why

(Continued on next page)

TURNOVER STRUCTURES . . .
(Continued from page 29)

have the extra weight of a 20G turnover structure when the seat belt separates at 7Gs and throws the pilot out on his head?

The law requires a single seat belt withstand only a 1,000 lb. load; but in my experience of static testing seat belts, I have found that even a light belt in good condition will take a 7G load (170 lb. man) without complete failure. The conclusion we draw now is that a 7G turnover structure should do the job, but let us consider one more thing. We should use a factor of safety in the design of our turnover pylon, and anyway we might have a strong seat belt that will take more than 7Gs. CARs state a minimum ultimate factor of safety of 1.50 be used in computing passenger loads. This regulation is a good guide, and we will use it here. The turnover structure should withstand 7Gs x 1.50 = 10.5Gs. If an airplane has a gross weight of 900 lbs., the turnover structure should withstand at least 9,450 lbs. (900 x 10.5 = 9,450).

If we put the turnover structure in front of the cockpit and do not wish to use the elaborate built-up military

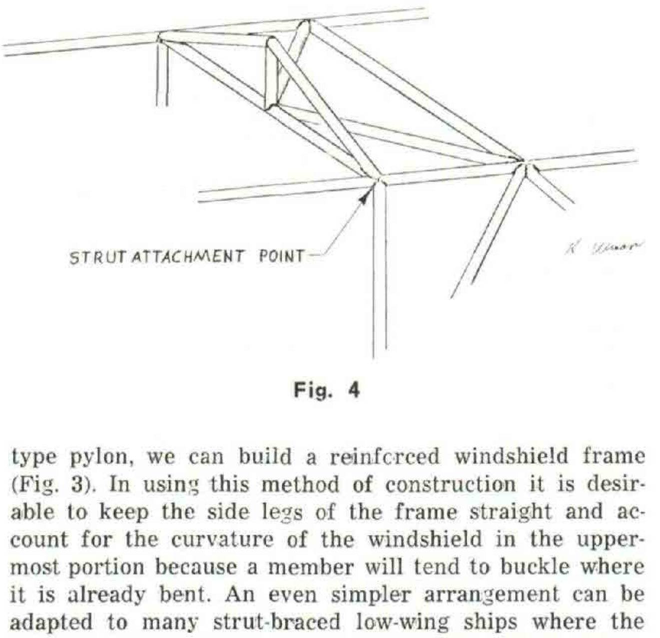

Fig. 4

type pylon, we can build a reinforced windshield frame (Fig. 3). In using this method of construction it is desirable to keep the side legs of the frame straight and account for the curvature of the windshield in the uppermost portion because a member will tend to buckle where it is already bent. An even simpler arrangement can be adapted to many strut-braced low-wing ships where the cross member of the fuselage at the strut attachment is reinforced against buckling as in Fig. 4. Fig. 5 shows the

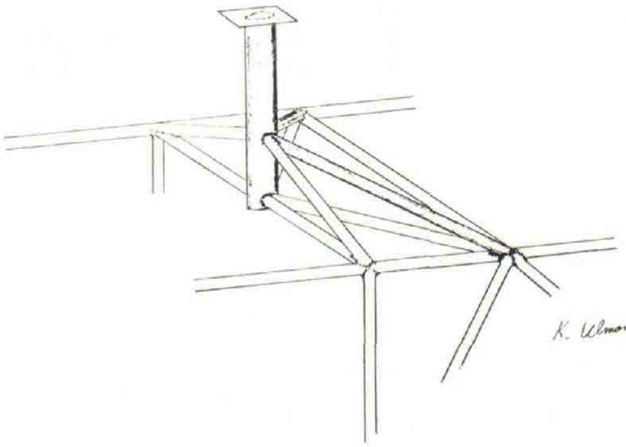

Fig. 5

structure slightly modified with the addition of two lateral brace tubes and a single tube pylon.

One is not limited to the use of steel tubes in constructing an overturn structure, but the strength of steel tubes in compression for various lengths can be found in many aircraft reference books if one is not too sharp on his column formulas, and it might be easier to get a more accurate estimate of the structure's strength.

These features should be incorporated in the design of all turnover structures: The top of the structure should have enough area to prevent surface penetration on impact. The structure should tie in with tube clusters or other suitable reinforced parts of the fuselage, and the structure should be braced against side loads which could be encouraged during an inverted slide. This may call for an oversize tube on the single tube pylon structure.

While we are on this unpleasant subject of turning over, let us once again go into the rule book. It says that the pilot must be able to exit from the aircraft easily if it turns over. It would not be nice to be trapped inside if the airplane caught on fire. We see many cardinal violations of this rule. The tilt forward, tilt aft, side hinged, and lift-off hatches could easily turn a low-wing conventionally geared aircraft into a pyre. A slide open hatch which can be left open for ground operations and take-offs and landings is best safety-wise. Also, an open cockpit should have sides low enough to permit easy egress.

The next time I see a guy with bum turnover protection on his airplane, I will tell his wife; and, if she is anything like mine, she will make him fix it. ●

Tax Relief . . . A Step In The Right Direction

A BILL granting real property tax exemption to private airport owners passed the Michigan legislature recently and is on the way to Governor John B. Swainson's desk for signature. The measure introduced by Rep. Joseph A. Gillis (D-Detroit), will exempt private airports that do not charge landing fees for non-commercial flights.

Gillis noted that private airport operators are taxed both directly by the aviation fuel tax and indirectly through property and other taxes, for support of publicly operated competitors. The Michigan constitution recognizes airports as a governmental function but private enterprise is providing a large number of aviation facilities in Michigan.

Michigan has 50 privately owned and 87 publicly owned airports excluding military and emergency fields. "There has been a downward trend in the amount of Federal money available for airport development. We must encourage the private airport operator who is providing important aviation facilities for use by the three largest segments of Michigan's economy, industry, agriculture and tourists", said Gillis.

"I consider the private airport operator the backbone of general aviation. This proposal will preserve needed aviation facilities at minimum cost and government control", said Gillis who has been a pilot for more than 20 years. Michigan became the second state, joining Massachusetts, to grant propery tax relief to private airports.