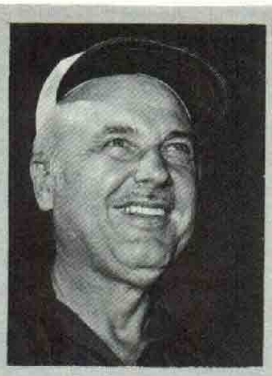


# THE SPORTPLANE BUILDER

*By Antoni (Tony) Bingelis*
*EAA Designee Program Advisor*

8509 Greenflint Lane
Austin, Texas 78759

# LANDING GEAR PROBLEMS AND SOLUTIONS

SHORT-COUPLED aircraft with narrow landing gears have long held the reputation for being "ground loopers". However, they are not the only aircraft with a propensity for this sort of behavior. Many homebuilts, generally considered to be quite manageable on the runway, seem to become ground loop prone when landed in a crosswind by a less than alert pilot or by one with limited piloting experience.

Of course, we are talking about taildraggers. Remember, however, that tricycle gear jobs are not totally immune from ground loops either.

I don't suppose any designer deliberately starts out to design his airplane to be a ground looper, but he sometimes accepts that prospect as a trade-off for other attributes he wants. Homebuilts with conventional landing gears can be designed so that their ground looping tendencies are reduced or eliminated along with other odd runway behavior. The application of a few helpful empirical rules for landing gear design should help us produce an aircraft that is free of landing gear induced difficulties.

A good landing gear design would be one that has adequate strength and good shock absorbing qualities. It must be properly located with respect to the aircraft's center of gravity (CG), and should have a generously wide stance (tread). Needless to say, adequate propeller ground clearance and good wheel alignment are also necessary. A design deficiency in any one of these requirements could result in a premature retirement of the homebuilt.

Other, more desirable design features would include a landing gear with large wheels so that unpaved runways can be used, and a gear of minimum weight to enhance the overall performance of the airplane. And, it would be nice, too, to have a landing gear that is easy to build and requires little or no maintenance attention.

## LANDING GEAR PROBLEMS

### Wheel Alignment

An airplane that is skittish and unstable on the runway may suffer from improper wheel alignment. Too much toe-in or toe-out, or a combination of both, can result in ground looping tendencies. Remember, the wheels must be aligned with the centerline of the aircraft as well as with each other. This is, of course, assuming that you are not a follower of the toe-in versus toe-out cult.

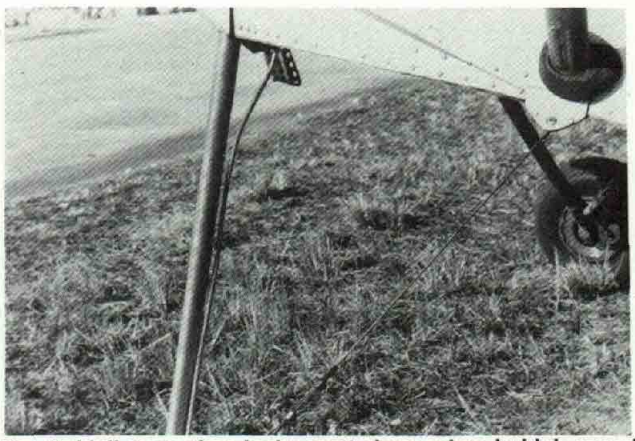
Alignment is easy to adjust in the slab spring landing gears and in some types of cantilever strut designs utilizing scissors. Tapered shims are added to the axle-to-leg connection in the spring gear to make the corrections for wheel alignment, while the addition or removal of washers between the scissor links is used to transmit a similar corrective adjustment to the axle and wheel of the cantilever strut gear.

Most other landing gears requiring wheel alignment will ordinarily have to undergo structural modification. This means, in most cases, a cutting away of the welds, re-jigging and re-welding. It is, therefore, important when building such a landing gear, to check and recheck its alignment to make sure both wheels will be parallel with each other as well as parallel with the centerline of the aircraft.

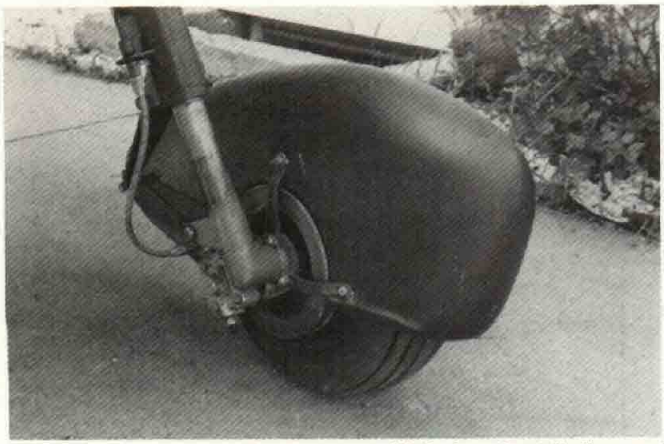
### Attachment Point

The comparatively large number of reported gear failures after landing is indicative of inadequate reinforcement of the landing gear attachments and inadequate diffusion of landing loads over a large area of


**Here's what one builder did to cure a fiber-glass gear that was too flexible. That wire axle is suitable only for good pilots and regularly mowed grass strips.**



**The "whip" gear often looks pretty busy when in high speed motion over rough terrain. The wire snubber is apparently intended to subdue that activity.**



**The scissors gear produces a very high drag installation and streamlining short of enclosing the entire mechanism in a large glob of fiber-glass is difficult. At the very least the upper gear leg should be streamlined.**

**And you think you have gear problems?**

the structure. Landing gears attached to wood fuselages need relatively large fittings to disperse imposed gear stresses. This requirement or need to disperse concentrated loads, is the same for aircraft constructed of wood, metal or composites. Sometimes the gear legs or struts break but such failures are much less frequent than the failure of welds and points of attachment.

The only real assurance a builder has that a particular landing gear he has designed has adequate strength is to prove it with a drop test. Because very few builders are inclined to drop their aircraft 18", or to set up an appropriate test module, it isn't too likely that much testing of that nature is going on. Since very few builders know how to set up such a test anyway, a stress analysis would be a more attractive alternative. In short, utilizing proven methods, and following traditional design and construction practices, can help you achieve the construction and installation of a stout landing gear free of runway idiosyncrasies.

### Gear Location With Reference To CG

In the air the airplane trims out perfectly for hands off flying with the trim set in a near-neutral position; the weight and balance checks out O.K., and yet, on the ground, you find the airplane to be too nose heavy. Yes, it does happen.

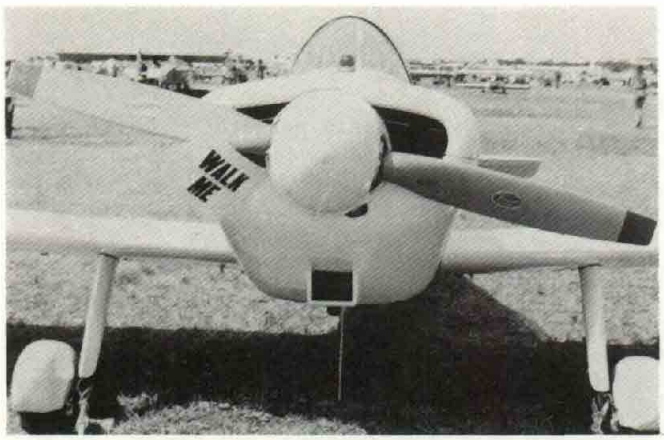
The landing gear often becomes an innocent heir to the consequences of the changes made during construction. For example, it is not uncommon for the builder to install a larger and more powerful engine along with a propeller-spacer and a metal propeller. All this weight sticks out ahead of the main gear. The weight and balance is O.K. even though it may be crowding the forward limit a bit. Nevertheless, the end result is a landing gear problem which hangs over your anxious thoughts like a sword on a silk thread.

Under the described conditions, most taildraggers with a full tank of gas and a hungry (lean) pilot aboard, will be very light on the tail wheel. The use of brakes becomes an exciting dare. For that matter, running the engine at higher rpms to check the magnetos sometimes becomes a visually dramatic act highlighted by the sudden, menacing rise of the tail before the startled pilot can yank the throttle back.

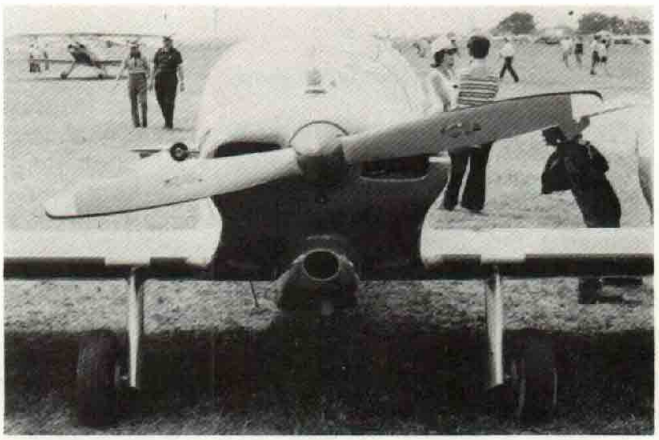
A slight error in the location or the welded angle of the attachment brackets, will cause the gear to sweep forward, or aft, quite a distance at the wheel end, and result in an inordinately nose heavy or tail heavy condition in the three point ground attitude.

If the wheels are too far aft in relation to the CG, the tail is very light on the ground and use of the brakes becomes traumatic. Engines, crankshafts and propellers are expensive to replace, and nobody needs to suffer the humiliation of a nose-over due to an improperly located landing gear.

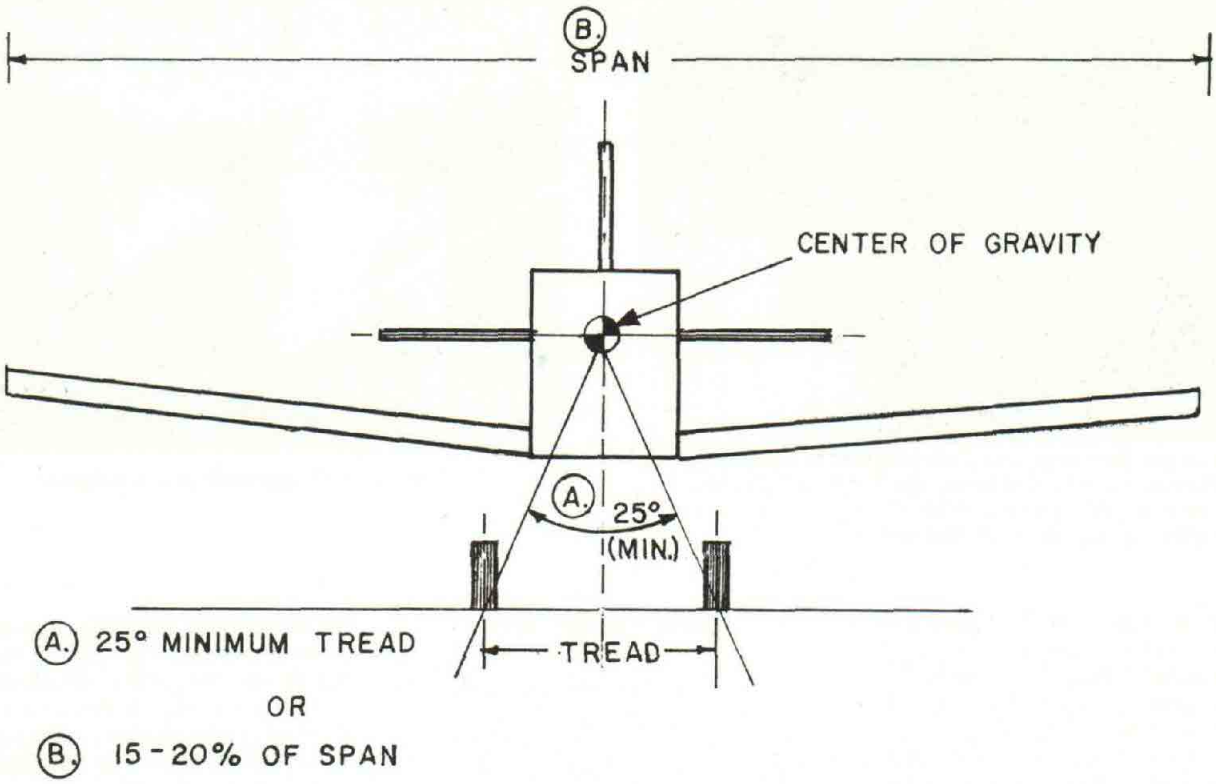
On the other hand, in the event the wheels are located too far forward, it will be hard to get the tail up during take-off, even though aerodynamic balance in flight is not affected. Consequently, on landing



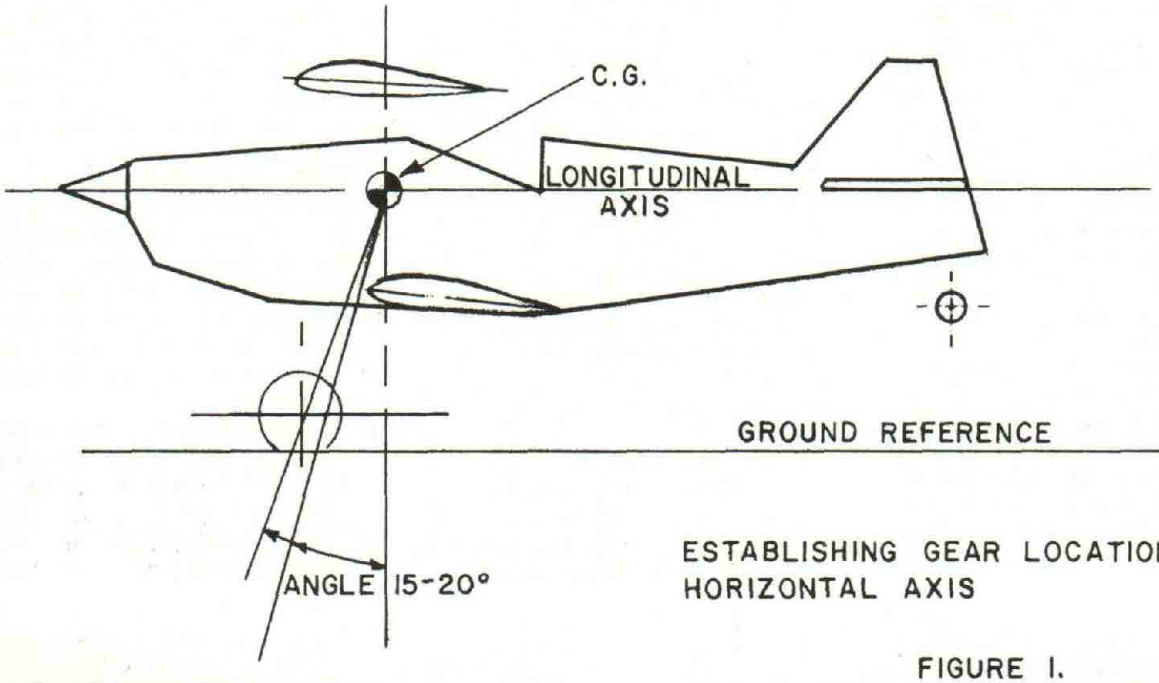

**A wide gear normally assures excellent runway handling qualities.**



**This gear is not wide but it isn't narrow either according to empirical design guidelines. But looks count for something too. A wide gear has that comfortable solid look.**




ESTABLISHING MINIMUM WHEEL TREAD




ESTABLISHING GEAR LOCATION ALONG HORIZONTAL AXIS

FIGURE 1.

the tail will drop suddenly on slowing.

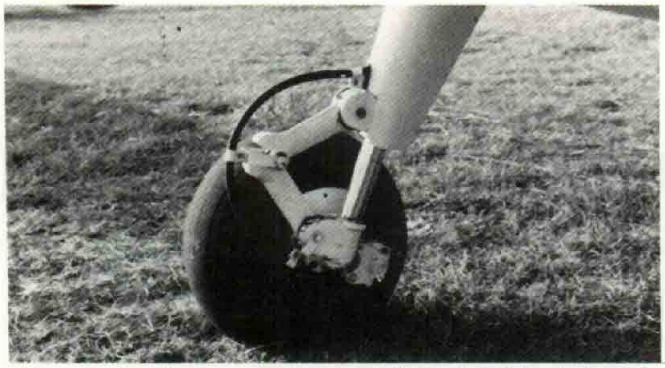
Figure 1 shows that, according to broad design parameters, the wheel tread should be at least 15% to 20% of the wing span. Another way of establishing the minimum acceptable tread is to insure that the wheel's points of contact with the ground will be outside of a 25° angle formed between the aircraft's vertical axis and the vertical center of gravity.

The gear location along the horizontal axis of the aircraft is generally determined as that point of contact with the ground established by a 15° angle struck from the vertical center of gravity. Wheels of a conventional gear aircraft are always ahead of the center of gravity (still talking about taildraggers). Just how much is usually the problem to resolve.

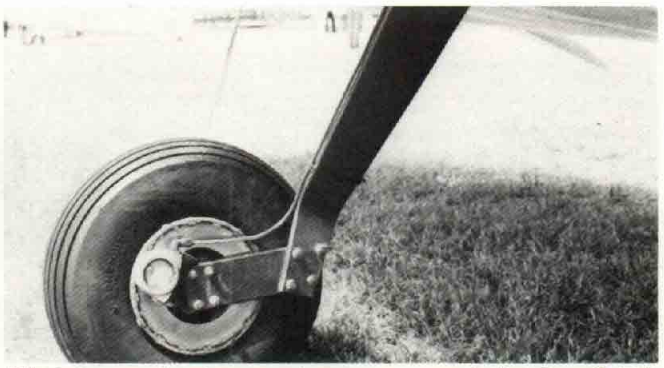
Knowing that his landing gear location in reference to the CG is critical, a builder should, when installing the landing gear, be sure to provide sufficient access for its total removal and reinstallation. Make a practice removal and installation at some time during construction to be sure. You may never need the easy access you make but at least you will gain peace of mind knowing that you would be able to remove and replace the landing gear without tearing into the structure.

### Jack Points

There will be a time when you have to remove the wheels and perhaps the landing gear, too. To accomplish those feats it will be necessary to jack or hoist the airplane in some manner. The simpler the better. You could remove the cowling and attach a hoisting hook to the engine and lift the aircraft that way.



**Who says landing gear scissors go in back? (Adaptation of a Piper gear.)**



**What do you do when you learn your gear is too far aft. This fix won't take the place of good design and planning but it seems to work.**

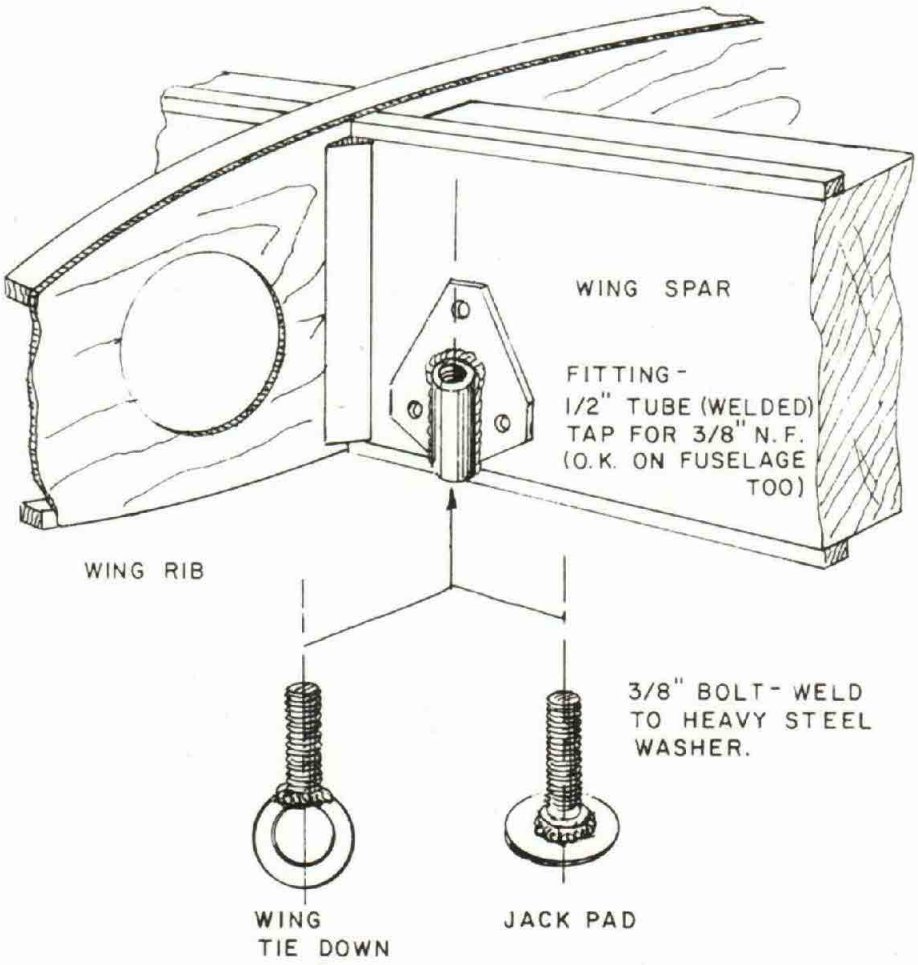



FIGURE 2.

After its up in the air, though, you will have to find some way to keep it from swaying while you work.

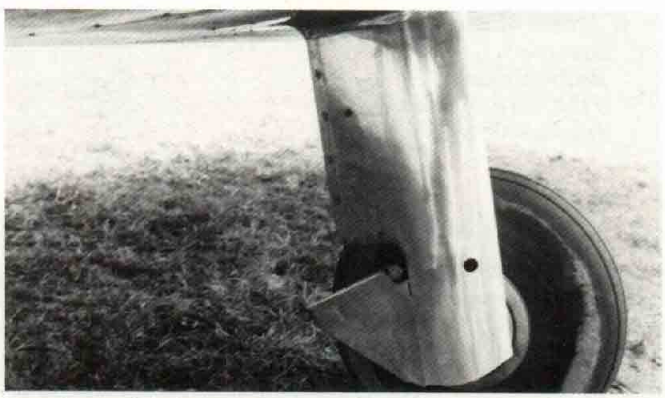
Jack points on the structure are a far better solution. Then either side of the aircraft can be jacked for the removal of the wheel or gear. A good location for the jack points? How about one on each side of the firewall. A fitting similar to the one shown in Figure 1 can be mounted flush with the bottom of the firewall. Anytime you needed to use it, a short bolt could be screwed in to serve as a protective spacer to keep the jack from rubbing against the fuselage.

Sometimes a small low-profile jack will fit under the stub of the gear axle (if yours is that kind) and the airplane jacked from that point. However, for most gear installations that method is impractical or simply will not work.

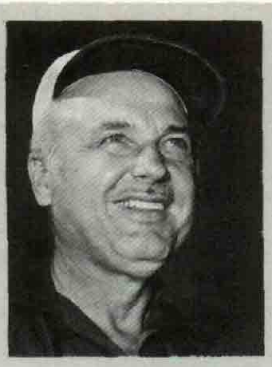
When work on a cantilever strut type of landing gear requires that the shock strut be disassembled, a jack under the axle would not permit you to undertake the job. All in all, the most versatile jack is a screw jack mounted on a small tripod custom-built for your airplane. A jack doesn't take up much hangar space so plan on using it regularly for changing tires, greasing wheel bearings, inspecting landing gear shock struts and for other purposes.

More next month.

**An example of an ultra light gear for a powered hang glider. At 30 mph drag is not a factor.**



**Ever try to fair in a strut type of landing gear with scissors. How's this for ingenuity?**



# THE SPORTPLANE BUILDER

*By Antoni (Tony) Bingelis*
*EAA Designee Program Advisor*

8509 Greenflint Lane
Austin, Texas 78759

## LANDING GEAR SHOCK ABSORBERS Part II

DESIGN AND BUILD your landing gear to take a lot of abuse. Abuse from hard landings, poorly executed crosswind landings, fast taxiing over rough ground and, perhaps on occasion, a sedate ground loop (ugh!). In addition, be sure that the landing gear legs of your conventional homebuilt (taildragger) are long enough to provide at least 9" of propeller clearance with the ground when the aircraft is rotated to a take-off attitude. The gear must also, in concert with the tail wheel, support your aircraft in a proper three point attitude. This will permit you to make 3 point landings at a minimum speed. Years ago the Cougars and some Tailwinds initially suffered from high landing speeds because the landing gear the builders used was too short to permit the required nose high attitude to be reached for full stall landings.

Among the preliminaries of selecting a landing gear design for your project is the determination of what wheels, brakes and shock system would be suitable. Big 600 x 6 wheels are fairly heavy and builders who opt to use them pay a weight penalty in exchange for better rough field operations. However, many homebuilts seem to function as well with the smaller lighter 500 x 5 wheels, and with the added benefit of reduced drag.

Roughly calculated, you will find that a conventional landing gear installation makes up approximately 8% of a two seater aircraft's empty weight. A modified J-3 Cub landing gear when adapted and installed in a homebuilt is really quite light. At the most, it might weigh as much as 50 pounds. In comparison, a cantilever strut gear will add about 73 pounds to the weight of an aircraft. Spring gears and rod (whip) gears generally fall somewhere in between the two weight ranges. Generally overlooked by the builder in figuring the weight of a landing gear is the necessary structural reinforcement and added trusses required for a particular installation. In short, landing gears weigh more than most builders realize and the selection of the best gear design for a particular homebuilt is never an easy matter to resolve.

### Rigid Landing Gears

Rigid landing gears, (no shock absorbers), are light in weight and are endowed with good runway stability but are, nevertheless, considered to be a rather primitive installation in spite of their good safety record. Not many designs, currently, feature a rigid landing gear . . . perhaps among those better known to homebuilders are the Volksplane and the Fly Baby. Both do have rigid gears and both rely on relatively large wheels and tires to absorb landing shocks. Incidentally, both aircraft have comparatively low landing speeds . . . an essential factor for this type of gear.

In rigid gear installation, the aircraft's structure (fuselage, wing attachments, engine mount, etc.) is subjected to more of the landing loads than it would be if shock absorbers were built into the landing gear. You would, therefore, have to determine if the structure and attachment points must be reinforced. If you expect to regularly operate your aircraft from rough or unprepared fields, the installation of a rigid landing gear is inadvisable as, in time, structural damage may result. Additionally, the landing gear itself might prematurely fail at the axles or in the weldments.

Balloon tires and larger wheels and tires can absorb some of the shocks encountered in landings, but although the larger wheels, and tires, partially inflated are helpful, they can also cause other unexpected problems . . . problems like pulled valve stems because of hard braking, or having a tire roll off the wheel rim in a hard fast turn-off from the runway.

Although rigid landing gears are lighter and easier to construct than most other kinds, their safe use is limited to slow light aircraft operating from smooth turf and paved runways.

### Tubular Gears With Shock Absorbers

The welded tubular type gear, better known as the J-3 Cub gear, is one of the lightest and stoutest landing gears you can build. It does require exact jigging and alignment during construction, because after installation no further wheel alignment will be possible without cutting and rewelding the gear. Some builders, therefore, rather than risk misalignment generally jig, align and tack weld the gear while it is in place on the aircraft. This type of landing gear is welded of 4130 steel tubing and seldom requires heat treatment.

Except for the added expense, streamlined tubing could be used for the landing gear V struts to reduce drag. Instead, most builders content themselves with covering of the gear leg V's with fabric or metal for aesthetic as well as aerodynamic drag reduction purposes.

The shock absorbers used with this gear are most often coiled compression springs or tightly wrapped under tension, bungee cords. Both types generate considerable drag and, therefore, should be installed out of the slipstream if possible. However, a lot of builders find it more practical to let it all hang out in the classical J-3 tradition.

This type of gear is always relatively narrow even though many builders attempt to make theirs as wide as possible for increased runway stability. Ordinarily, the builders' objective is a good one but some of them are frustrated by the need to maintain sufficiently large angles between the strut V's to develop strength characteristics normally required of a triangular structure.

Most of the modifications to the basic J-3 gear are made by builders

of biplanes and high wing aircraft . . . the most frequent users of this type of installation. You find that their bigger airplanes are equipped with the bungees buried inside the fuselages while the smaller aircraft will be fitted with externally exposed shocks that may or may not be encased in streamlined cuffs.

Biplanes, because of their high vertical center of gravity, impose severe service requirements on bungee equipped landing gears. It is important, therefore, to check that the shock cords in these aircraft remain in good condition and are kept tight to insure reasonable runway stability.

Shock cords are highly resiliant when first installed but deteriorate quite rapidly. Primarily, I suppose, because they are under constant tension and are, furthermore, subjected to the contaminating and damaging effects of exhaust gases, fuel, oil, dirt and pebbles thrown up by the propeller during ground operations.

Builders using shock cords in their landing gears also install a short loop of 1/8" control cable as a safety restraint "to catch" the airplane in the event the shock cords give up suddenly. In reality, shock cords do not give up suddenly. A thorough preflight inspection of the bungees insures that you will be given sufficient advance warning of impending failure. During your preflight inspections of the shock cords, look, in particularly, for any part of them that may seem to have a thinner than normal diameter . . . it could be an indication of a forthcoming collapse. Suggested additional reading . . . *SPORT AVIATION* May 1973, page 48 — Bungee and Spring Shock Absorbers.

### Cantilever Strut Landing Gears

The cantilever or strut type of landing gear is one of the finest landing gears around and is ideally suited to low winged aircraft. They are rather heavy but are virtually maintenance free. There are many kinds of cantilever strut gears.

Homebuilders being an enterprising lot, find the idea of modifying and installing a landing gear salvaged from some production aircraft very attractive. The inducement usually stems from some reasonable cost for a salvaged gear and from the realization that much work and construction time will be saved.

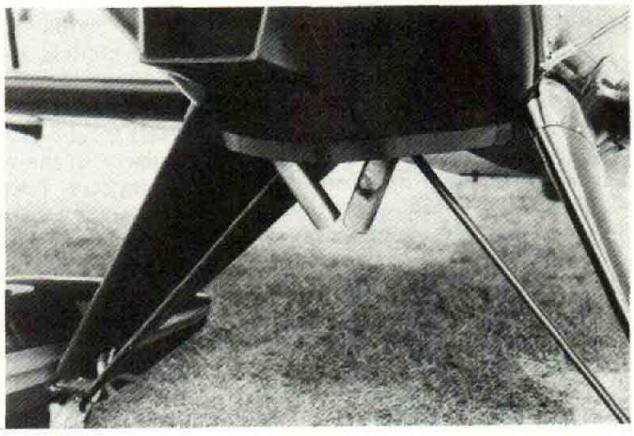
Those featuring hydraulic shock absorbing units (Aerol, oleo spring, pneumatic, or whatever) are rarely used in homebuilts. The Pazmany PL-1 and PL-2 designs do feature such a gear. However, hydraulic shock struts, if found on a homebuilt, more than likely, would have been cannibalized from some production aircraft and adapted for use by the builder. Such gear units are more complex to build and require some machine shop work. In addition, the gear is somewhat fussy when compared to the simple slab spring gear or the whip gear, and does need more care and maintenance than most others. Therefore, if a cantilever strut gear with a hydraulic shock feature is desired, most builders will try to salvage a landing gear from some aircraft rather than undertake building one from scratch. This strikes me as being a matter of good judgement provided the gear selected is not too heavy. In addition, in the event of some future gear damage a similar replacement gear can often be found.

Other kinds of cantilever strut shock absorbers are more frequently installed in low wing homebuilt aircraft than are the oleo types. Many landing gears of this type now incorporate a coiled compression spring for the shock absorbing element of the gear. It makes an excellent gear and absorbs the lesser shocks of taxiing over the rough ground as efficiently as it does the occasional hard landing. Landing shocks are dissipated smoothly without tossing the airplane back into the air as is characteristic of some types of landing gears.

The main load carrying compression springs used in cantilever strut gear legs vary quite a bit but, surprisingly, the results obtained seem to be equally good. One gear I examined, recently, got by very well using a 9" compression spring made of 15 coils of .344" diameter wire while another two seater using larger gear legs depended upon a bigger spring almost 18" long and made of 26 coils of .356" diameter wire. The latter, of course, was a heavier landing gear although both aircraft were in the 1500 pound gross weight category. Rubber pucks could probably be substituted in either gear with some savings in weight. The longevity of rubber pucks, however, may be somewhat limited compared to that of the compression springs.

These vertical strut landing gears require the installation of externally mounted scissors or splines to keep the axle and the lower gear leg from swiveling around inside the main strut. This requirement contributes to a rather aerodynamically dirty installation. Most European designers now cope with this problem by encasing the entire gear leg and scissors in large bulbous wheel pants which lend a unique appear-

**A rigid tripod gear being fitted to a Volksplane 1. Is this an improvement over the original rigid aluminum slab gear?**



**The high vertical c.g. of a biplane coupled with the high landing speed and relatively narrow gear combine to make this type of airplane pretty frisky on the runway.**

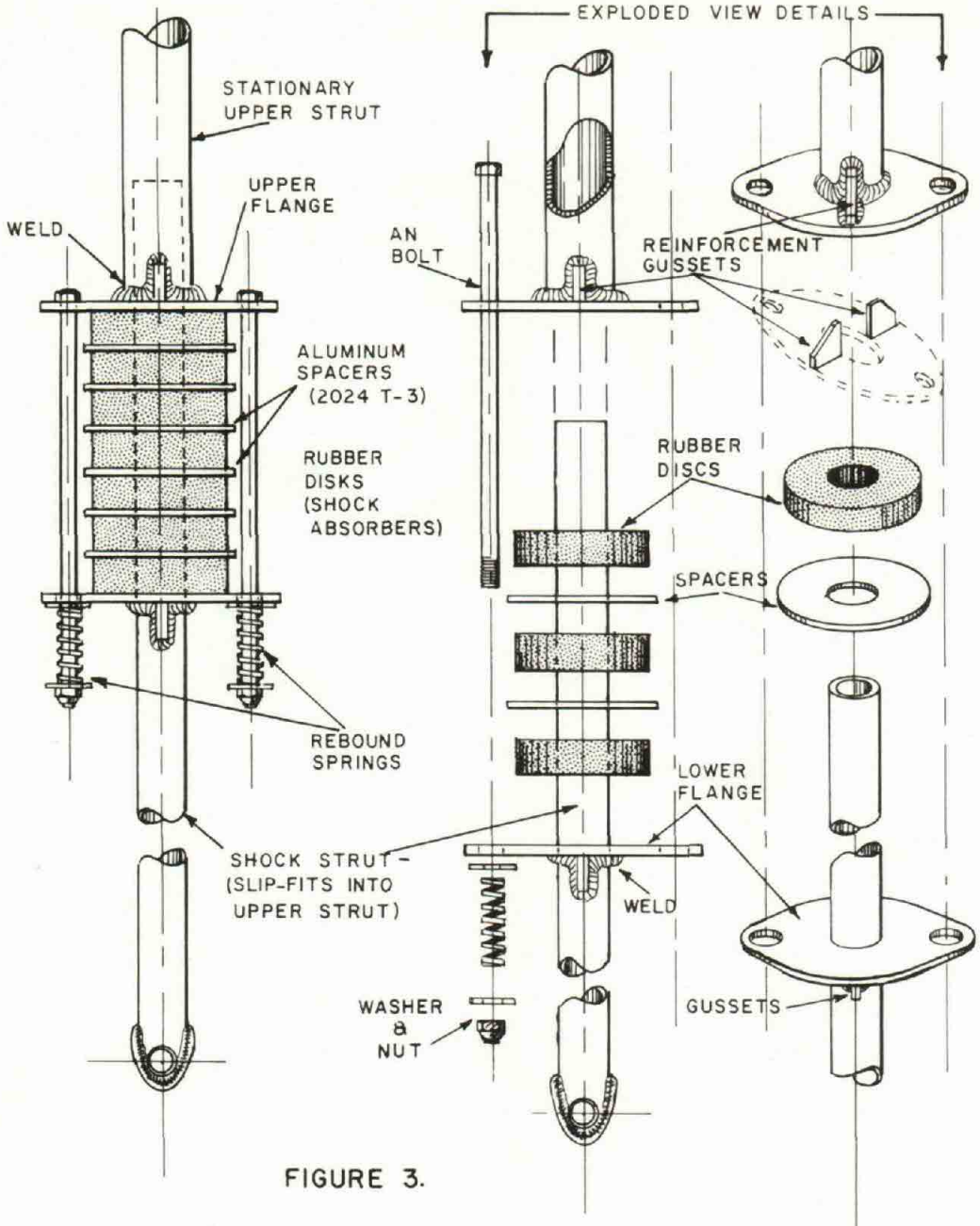
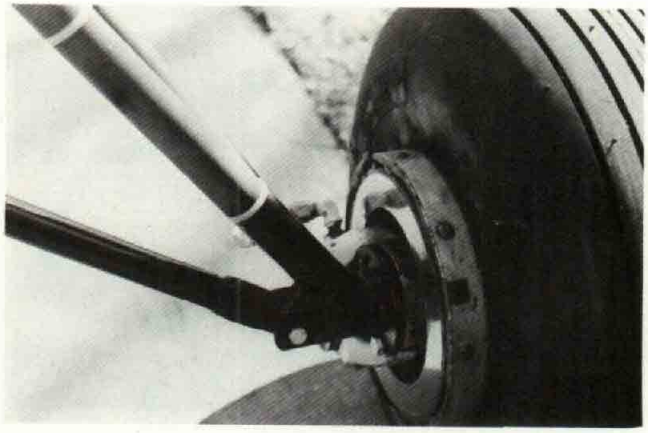



FIGURE 3.

VERTICAL SHOCK STRUT
(FOR ULTRA LIGHT AIRCRAFT)

**A variation of the old J-3 Cub gear complete with bungee cords hanging out in the slipstream.**



**Axle treatment for the welded tube tripod gear installation.**

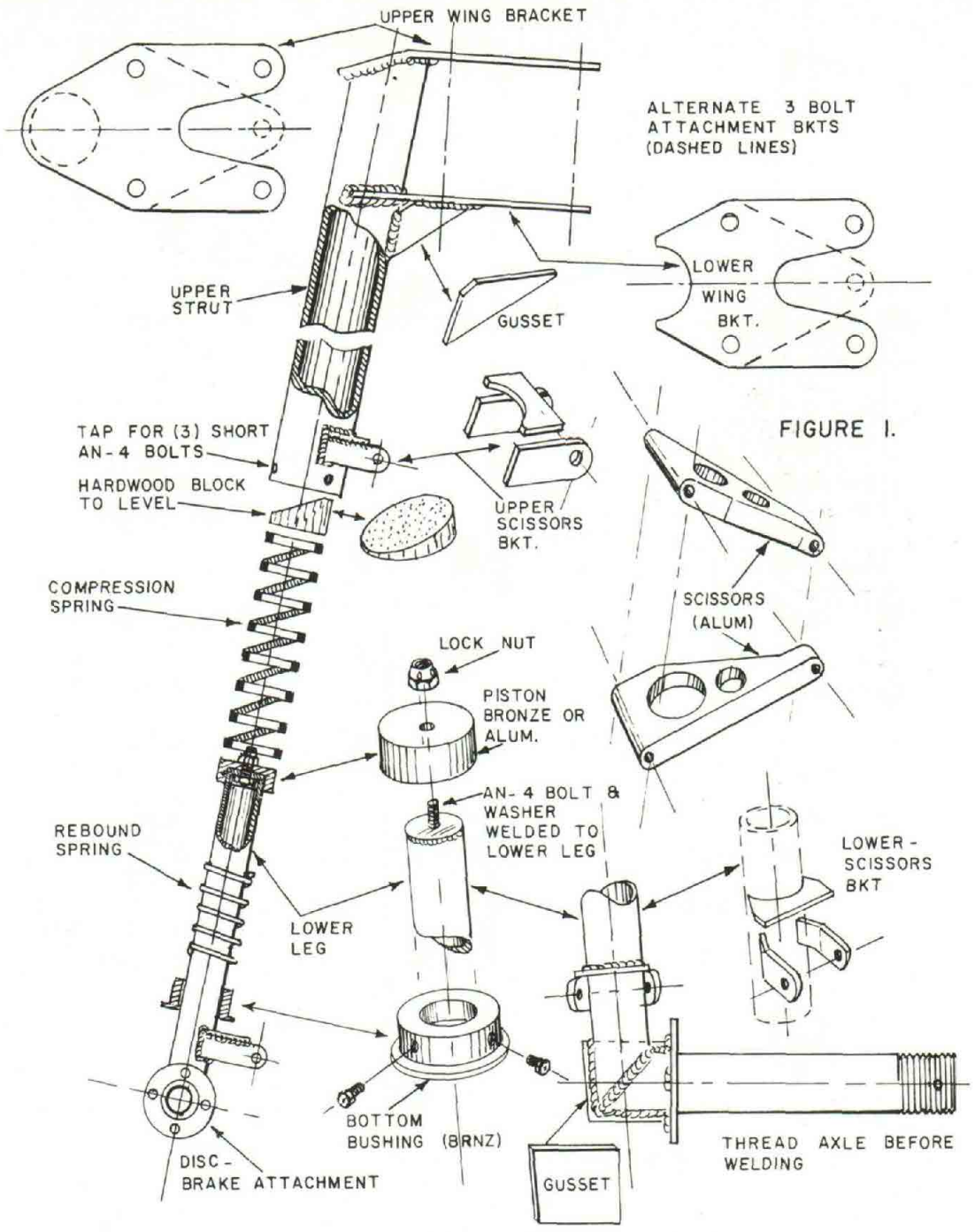
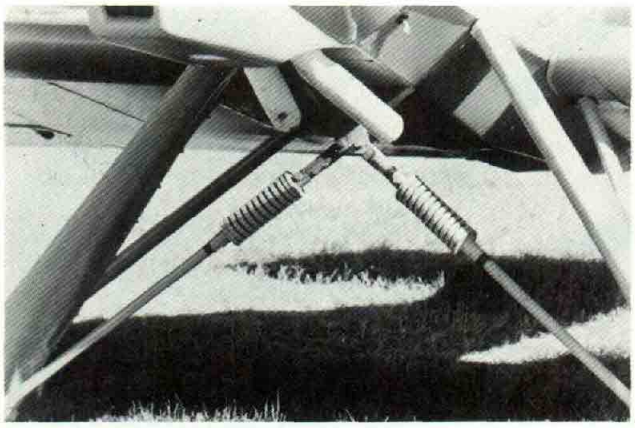
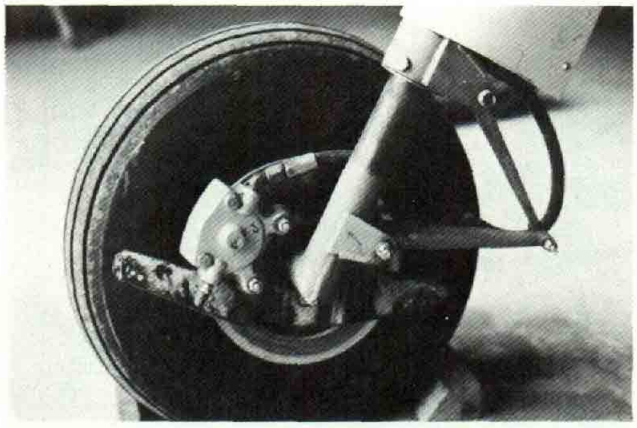



FIGURE I.

CANTILEVER STRUT LANDING GEAR



Typical compression spring shock installation.



The classical cantilever strut gear complete with scissors whose function it is to maintain wheel alignment. Unfaired it is a high drag gear.

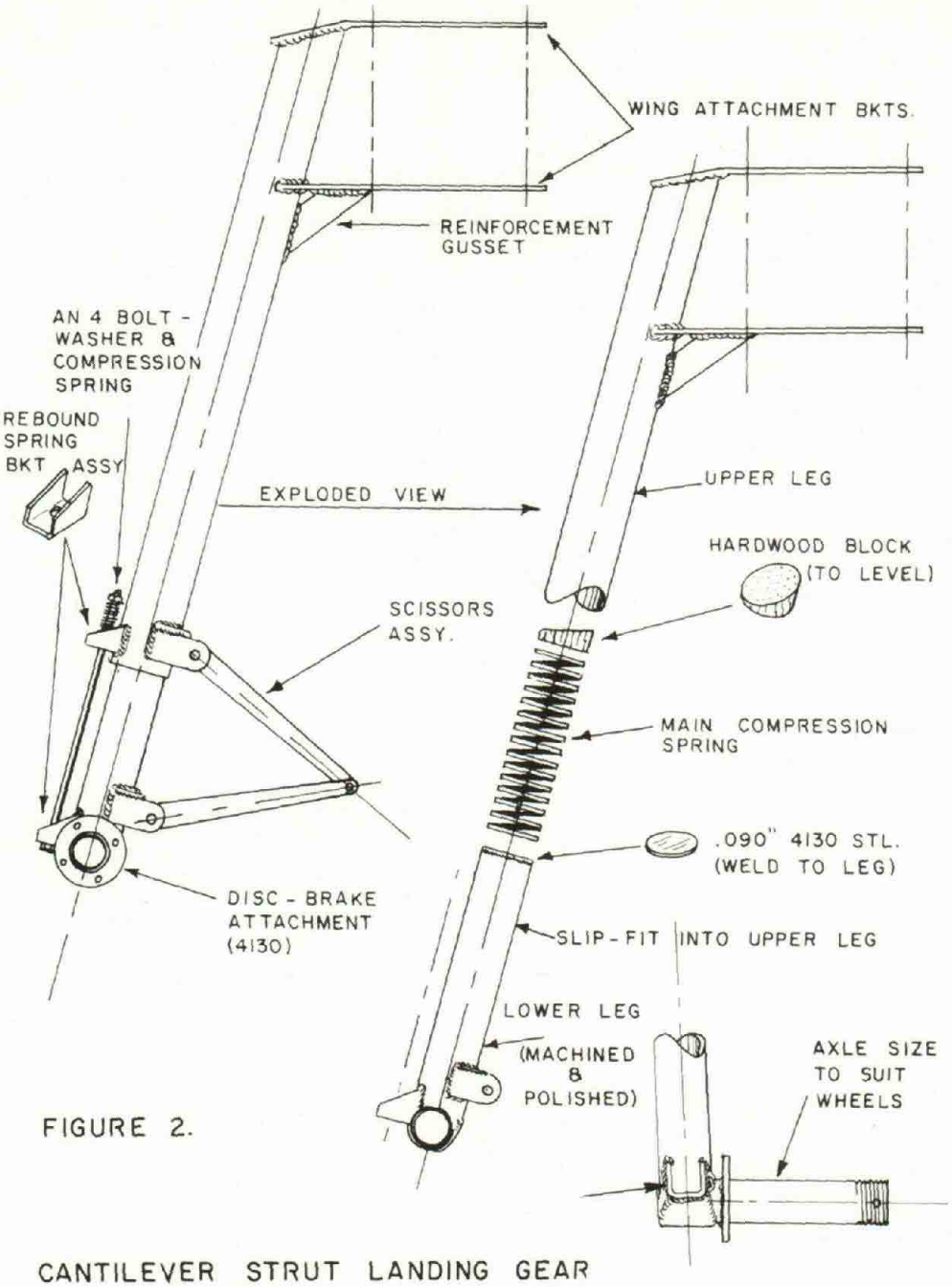
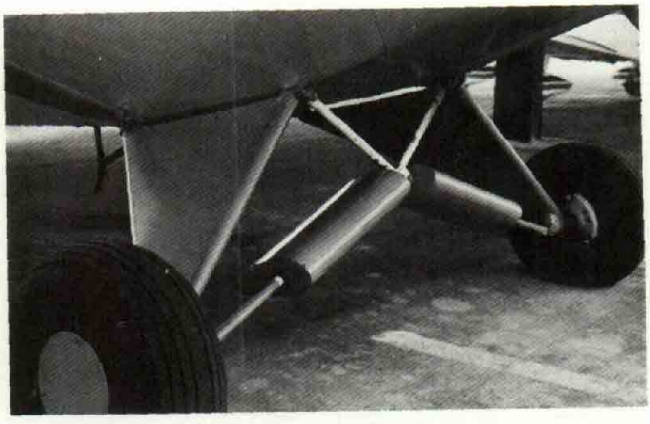



FIGURE 2.

CANTILEVER STRUT LANDING GEAR
(A VARIATION)

**This Skybolt gear has its bungee hidden inside the fuselage and the landing gear V's are being covered with aluminum instead of fabric.**



**Ever see a streamlined "Cub" gear?**

ance to the aircraft. Although the cantilever strut landing gear utilizing compression springs or rubber pads is simple in its design and execution, it is difficult to build. At least two pieces must be machined. One is a piston-like cap for the lower leg and the other is the lower bushing. In addition, the welding of the scissor attachment brackets can cause severe distortion in the lower main strut area and make it difficult, if not impossible, to insert the lower leg with its slip-fit piston. It is suggested, though, that the heliarced elements be torch-heated to a dull red condition to stress relieve the area.

A simpler version of the cantilever strut gear leg may be made using a larger size of tubing for the upper leg and a smaller tube which fits easily inside that tube. This removes the need for machining of bushings or pistons as the inside of the tube becomes the bearing surface. The lower leg simply has a large washer welded to the top of the lower leg and the main compression spring rides on it. The rebound element in such an installation is usually a small compression spring or rubber bumper added to a splined-like set up. Figure 2 should clarify this verbage for you.

### The Tapered Rod Or Whip Gear

The most attractive feature of the rod gear is in its simplicity. Even the installation can be simple with a sleeve welded into the lower engine mount. However, mounted in other installations complexity of installation increases. The gear is light in weight but is also found by some builders to be too flexible for their aircraft. The flexibility often causes excessive wing wobbling during ground operations and sometimes during take-off and landing, a rapid cycling of toe-in, toe-out, and camber occur. This induces a runway control problem and excessive tire wear. The round rod spring gear has quirks that many builders do not like. There is very little stability in the gear legs because they will flex erratically in all directions while, at the same time, they will twist on all but the smoothest of pavements. This produces a tendency to shudder torsionally with the vibration being transmitted through the entire airplane. In some installations, it proves to be very stiff during taxiing and provides a rather rough ride. Mechanically the gear would seem to be a great solution to the homebuilder's landing gear problem. Undoubtedly a lot of the reported problems stem from gear legs that are mismatched to the aircraft's weight. Improper design and installation could account for additional difficulties. The gear legs should be faired to reduce drag. This, in itself, can be a challenging effort because the gears flexibility makes the accommodation of a fairing difficult.

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## CONGRESSIONAL RESPONSE . . .

**(Continued from Page 38)**

I appreciated hearing from you on this important issue.
Best regards.

Sincerely,
John Glenn
United States Senator
Washington, DC

Mr. R. W. Manetta
2519 Crawford
Terre Haute, IN 47803

Dear Mr. Manetta:

Thank you very much for contacting me regarding your objections to the proposed FAA right-of-way regulations.

As Chairman of the Transportation Appropriations Subcommittee, I have done what I can to make sure that adequate safety precautions are considered for air traffic. The alternatives that you brought to my attention appear to be most reasonable, and I have asked the Federal Aviation Administration to take a serious look at the EAA's alternative plans. As soon as I receive a report on this matter, I will be back in touch. In the meantime, I trust you will feel free to let me know if there is anything further I can be doing to help.

Again, thank you for keeping me posted.

Sincerely,
Birch Bayh
United States Senator
Washington, DC

Federal Aviation Administration
Office of the Chief Counsel
Attention Rules Docket AGC-24
800 Independence Ave., SW
Washington, DC 20591

Re: NPRM Docket Number 18605
Notice Number 78-19

Gentlemen:

I write to advise you of my strong objection to the FAA proposal to massively extend positive control of United States airspace. It's an obvious over-reaction to the mid-air collision over San Diego, California and in my opinion as a former military pilot and the holder of commercial, multi-engine and instrument ratings, it will simply create a horribly expensive bureaucratic nightmare.

The function of the FAA is not to create jobs for bureaucrats and expense for aviation, whether it be general or air carrier. Its major reason for existence is to structure air traffic so that it provides as safe as possible climate for airspace users. The proposed plan fails miserably to accomplish additional safety for those users.

The creation of the new Terminal Radar Service Areas is an absurd fait accompli if they are to be used to prohibit general aviation flight in the future without positive control. Safety of flight in its most basic component is dependent on the ability of pilots and passengers to see and to be seen. The FAA proposal will not further that possibility.

The Terminal Control Areas function like a sod covered landing field in the jet age. The FAA should recognize the efficiency of climb and descend corridors that the military used. Simply making those corridors prohibited areas would increase Terminal Control Areas efficiency for safety purposes many fold without additional bureaucracy and expense.

Both aircraft at San Diego were under positive control. To the extent that the FAA would put some of the airport trust fund money into "Reliever" airports in major cities accomplished separation could be made without the incumbent bureaucracy and expense inherent in the FAA plan.

Probably the only word to describe the proposed positive control airspace restriction is "absurd" unless, of course, the objective is to create jobs for the bureaucracy and add expense to the hundreds of thousands of VFR pilots who fly in these areas.

I fully support FAA proposals that will sensibly enhance aviation safety and I urge you to carefully consider the positive and sensible response to the proposed changes made by the Experimental Aircraft Association of Hales Corners, Wisconsin.

Very truly yours,
Norman E. Gaar
U. S. Senator
State Capitol
Topeka, KS 66612

From: Ray Arvin, Director, Aviation Division
Kansas Department of Transportation

House Resolution No. 6020
By Representatives Ferguson and D. Heinemann
2-15

A RESOLUTION relating to the Federal Aviation Administration's proposed increase in the national airspace in which air traffic control is required.

*Be it resolved by the House of Representative of the State of Kansas:* That the House of Representatives finds that the recently announced program of the Federal Aviation Administration to drastically increase the national airspace in which air traffic control is required (proposed "controlled visual flight" rules, 44 Fed. Reg. 1322-33, January 4, 1979) is not in the best interests of the people of Kansas; and

*Be it further resolved:* That the House of Representatives believes that this program will adversely affect general aviation and is being fostered in apparent disregard of the importance of general aviation to the national interest and the interest of the people of Kansas; and

*Be it further resolved:* That the Chief Clerk of the House of Representatives be directed to send an enrolled copy of this resolution to the Federal Aviation Administration for inclusion in the record of its proceedings relating to the proposed visual flight rules.