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T-18 NEWSLETTER 37 October 16, 72

L. D. Sunderland, Editor, 5 Griffin Dr, Apalachin, NY 13732

OSHKOSH 72 - There was a nice crop of new T-18's at the Fly-In this year in spite of a solid weather front stretching from the Atlantic coast to the Rockies which kept many from making the trip. Lloyd Toll and Dick Walen are to be congratulated on winning the T-18 awards and there were many others very deserving of commendation for the fine workmanship. It would really be worthwhile for every builder to make the trip to Oshkosh at least once before completing your T-18 so you can see how you should set your standards. Especially in the upholstery and exterior finishing areas, some people do a poor job and ruin an otherwise fine airplane's appearance.

There were several interesting variations which deserve comment. One was a further variation on the modification made by the Tiger Club from Marietta, Ga. George Fugate, N7199, put conventional dihedral in the wing. It is made the same as the standard wing except that the joint between inner and outer wing is overlapped and the main spar is spliced in the center, BL-0. It is one of the heaviest T-18's now flying with a weight over 1000 lbs. although I don't know how much is due to the wing modification. Tell us more about it George.

A second new mod was Ron Zimmerman's wing tips. As a result of the test program at Mississippi State U, Ron thought he might get a slight improvement by changing tips. He said there was a slight inwash at the trailing edge of the tip which effectively reduces the effective span by the amount of total inwash. He made new tips with the same planform but a large amount of camber at the outer edge somewhat like the Yankee tips. He reported disappointedly that they lowered the maximum speed but did cut stall speed by 3 to 5 mph. Later he reported that the loss in speed was due to a sticking carb heat valve and that he thought he actually gained 2 mph.

Bob Young had the most enviable control surface trailing edges. He did what many of us wondered about but didn't do, make both sides of the surface from one piece with the trailing edge simply folded over. It must have worked for there were no cracks. He also did a fantastic job of filling rivets to hide them. Tell us more Bob.

T-25 THORP SELF-LAUNCHED SAILPLANE - John is currently working on the design of a powered sailplane which will probably be the T-25. This is the design I've been waiting on and would like to make my next homebuilt. It will be some time before it is completed so don't bother him with questions. With a T-18 and a T-25 in the barn, who'd want more

T-18 PARTS SOURCE * John Thorp is starting a new venture as a service to persons building the T-18. He has formed a new organization called Thorp Aircraft which will supply some of the more difficult parts to fabricate. For instance, he has tooled up to produce metal cowlings, landing gears, crankshaft extensions, exhaust systems, engine mounts etc. He will also supply skins marked from his original templates. He is not yet supplying complete kits, but is fabricating certain parts. This is a good opportunity for those of you who need help. Write to Thorp Aircraft, Box 516, Sun Valley, Calif 91352 with your specific requests and he will give details and prices.

WOODEN PROP (Footnote to item page 7) Sensenich is charging $500 to develop the new wooden prop and Dick Walen will test it on his new O-360 as a favor. If it works well we'll get wood prop designs for the smaller engines. So, how about donating to the cause? Thanks!

TUFT TESTING THE T-18 - Peter Garrison has been commissioned by Flying Mag to write an article on tuft testing. For this John Thorp tufted his entire T-18 and had in-flight pictures taken from all angles. He says the airflow is perfect except around wheel pants. Watch for artic

LEN EDVINSON'S T-18- 2204 Camas Circle, SE, Renton, Wash 98055 - On a recent trip to Seattle, I visited Len and got a ride in his nice T-18 (150hp). It is really a smooth one with every rivet filled on the external surfaces, making them quite invisible. The workmanship makes me want to build another T-18 to get a second chance. Len, a former Boeing engineer, is design engineer for a firm which sells laminated fiberglass fabrication equipment. They are designing an all-fiberglass powered sailplane a la Hummingbird which they hope to have at Oshkosh 73 and offer in kit form to homebuilders. Len made some interesting variations which are worth noting.

Fuel tank - As you know, the standard fuel tank filler cap was made exposed for simplicity but I strongly recommend enclosing it for it spoils the looks of a beautiful airplane and the extra door adds little work - probably less time than you would take hunting a molding. Also, hiding the cap allows you to use an alternate cap since the standard one is almost impossible to build. Some builders who enclosed the cap had a clearance problem with the door latch. Len solved this by hinging the door outward. He used a combination of aluminum and fiberglass to make the tank. The ends were made of fiberglass like my tank, over male molds, but instead of making the center of fiberglass sheet, he used a sheet of aluminum. Tank ends had a strip of aluminum cemented inside the lip. Assembly was accomplished by wrapping the center sheet around the ends and securing with closed-end Pop rivets. An epoxy fuel tank sealant was first applied to seams. The filler neck and other fittings were attached in the same way. Sealant was then sloshed around inside and Len reports no sign of fuel leakage. The ends were made full-strength over the molds, so no additional layers are added on assembly as in the all glass process.(Don't forget reserve outlet when you make your tank.)

Oil Cooler - Len used the largest Corvair cooler but mounted it in an unusual location on the bottom side of the bottom cowl just forward of the firewall on BL-O. Air enters through a metal scoop, turns 90 deg and flows up through the cooler. The scoop is hinged on the aft side to allow inlet adjustment. With 3/4" opening it gave adequate cooling. Although the scoop adds drag it looks like good idea

Tail Spring - Although the Zimmerman type round tailspring is probably the softest I've seen, Len's was very impressive. It was a standard 3/4" spring with 2" extra length. His main gear was the same as mine (outer tubes tapered and inner legs 2½" longer) but the ground ride was softer probably due to the longer tailspring. My 5/8" spring is a big improvement but Len's is probably softer. The only dis-advantage of the long spring is that it increases the moment on the fuselage attachment fittings. So far, this hasn't caused a problem however. I haven't ridden in a T-18 with one of John's new steel leaf springs yet, but he says it is also softer. Whatever you do, don't use the old standard 3/4" thick tailspring. Len's tailwheel steering springs were too soft and I could hardly keep the airplane on the taxistrip. If you have ground handling problems with a T-18, it is probably due to these springs. Mark my word, if you don't hook these springs up like I suggest with an extra loop of chain and bend the hooks so they can't come off, sooner or later you will ground loop. I didn't get to takeoff or land Len's airplane because I had to hold my left leg up over the stick due to limited stick motion with the center console. T-18's with center consoles should be placarded agai- carrying passengers with stick installed if they are over about 5' 11".

Pitot Tube - Len forgot to put holes in the fin ribs for the pressure tubes so he put a long probe on the wing. Usually, this results in bad airspeed readings around stall, but Len's looked pretty good there. At full throttle, it would indicate only about 145 mph which was quite a bit low. If you have forgotten the holes in the fin ribs, I suggest you weld a drill bit to a long rod and go to work. It works, for that is what I did! It is worth it to get a good airspeed reading and keep the pitot tube up where it won't bump into you when you aren't looking.

PROPELLER VIBRATION TEST RIG - Dean Davis and Howard Henderson, 444 Bryan, Kirkwood, Mo., 63122 -- An attempt has been made to devise a method to vibration test propellers with the kind of equipment normally available to the ham radio hobbiest. The attached sketch shows the test setup we have used successfully to identify the non-rotational resonant frequencies of a propeller. See Fig. 1.

The readout device is made from a small portable radio and a communications receiver. The transistor radio serves as a noise free source of frequency modulated signal which can be picked up by a good general coverage receiver. The combination of the aluminum plate and propeller acts as an extension of the local oscillator capacitor of the transistor radio providing modulation. The speakers are used to drive the propeller. Best results were obtained with the fairly expensive ($15) flat response 8" diameter type but we got some data with $1.50 6" cheapies. Ed Note: The prop must be suspended on a bungee attached to the hub for this test to be valid. A complete discussion with equations for converting to rotating frequencoies will appear in my article entitled "Propeller Fatigue" in the November, 1972 SPORT AVIATION. It describes a mechanical shaker and strobe light test rig. It is too long to print here. Static tests aregood indications, but are not as reliable as an in-flight survey.

NEW SENSENICH PROP TESTS - Henry Rose just informed me that Sensenich has completed vibration tests on the first new 76 EM6-8-72 propeller and it has very good characteristics. The first mode, second order is at 2780 rpm, the 2nd mode, 6th order is at 2560 and the 3rd mode, 10th order is at 2945. Since the in-flight tesys showed that the stress level of the 2nd mode, 6th order was below the fatigue limit level, the new propeller will have a green range up to the engine red line of 2700 rpm.

This propeller is now available new and can be ordered only direct from the factory for $290. (Sensenich Propeller Corp., Box 1168, Lancaster, Pa., 17604). Specify engine model and horsepower.

Note that this propeller uses 5/8" attachment bolts but is as thick at the hub as a standard 76EM prop (which uses ½" bolts). This requires using some "persuasion" on the front spinner bulkhead to re-form it if the spinner bulkheads were originally made for a 74DM prop. If you buy a spinner from B. Pershing Larson in Chicago, he will send the proper bulkheads pre-drilled to fit your specified propeller. The new propeller has a different hub thickness and bolt diameter combination than either the 74DM or 76EM. George Leider is buying the first one and will test it on his 150 T-18.

SENSENICH PROPELLER DESIGNATIONS - There is no doubt some confusion about Sensenich's propeller designations since they have changed recently. For instance, a 180 hp Cherokee propeller was designated M76EM-0-60. The first M differentiates a metal from a wooden prop and has now been dropped since only metal props are now in production..

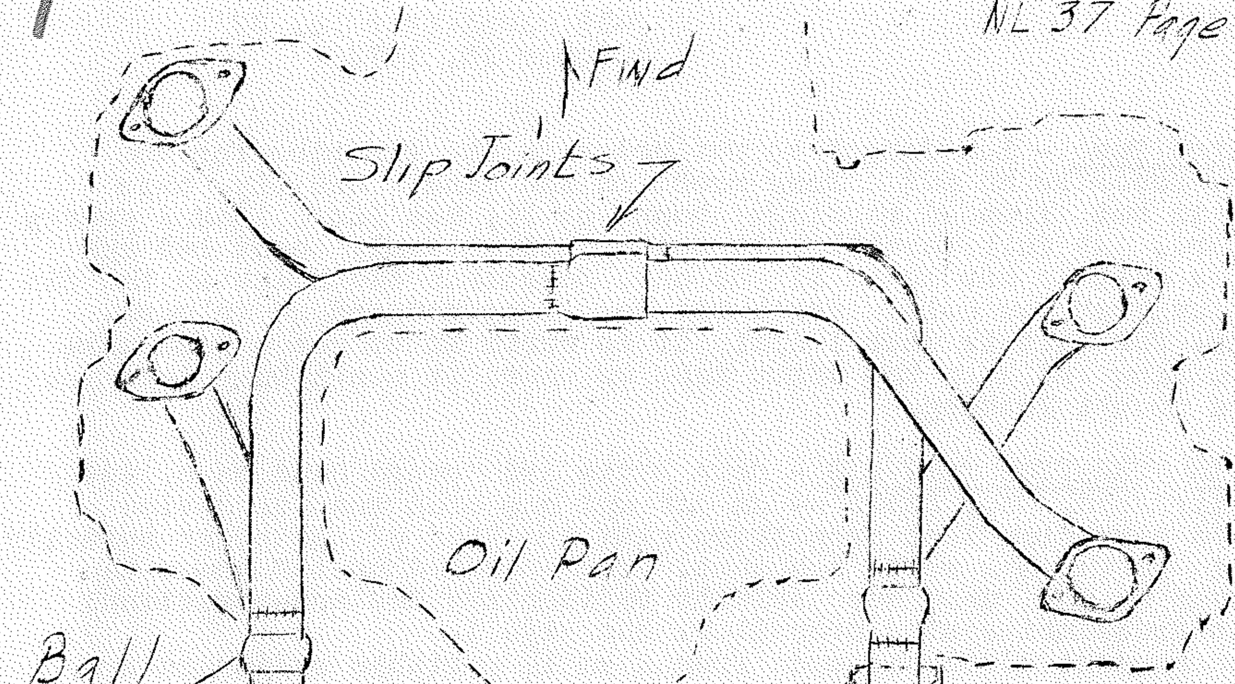
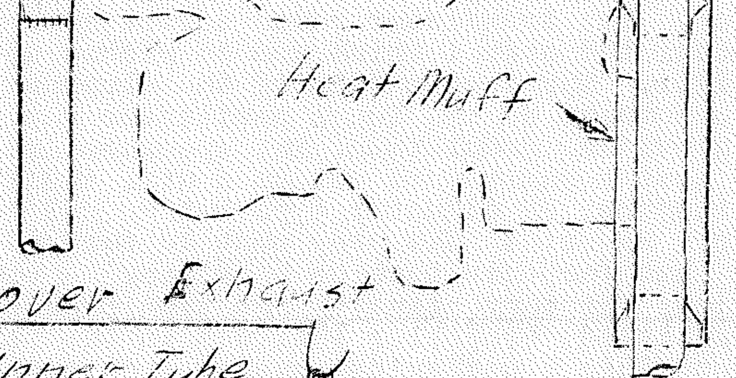

Fig 5 Crossover Exhaust

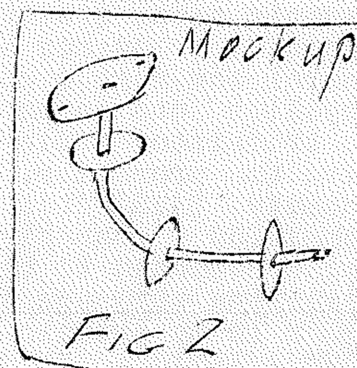

Fig 2

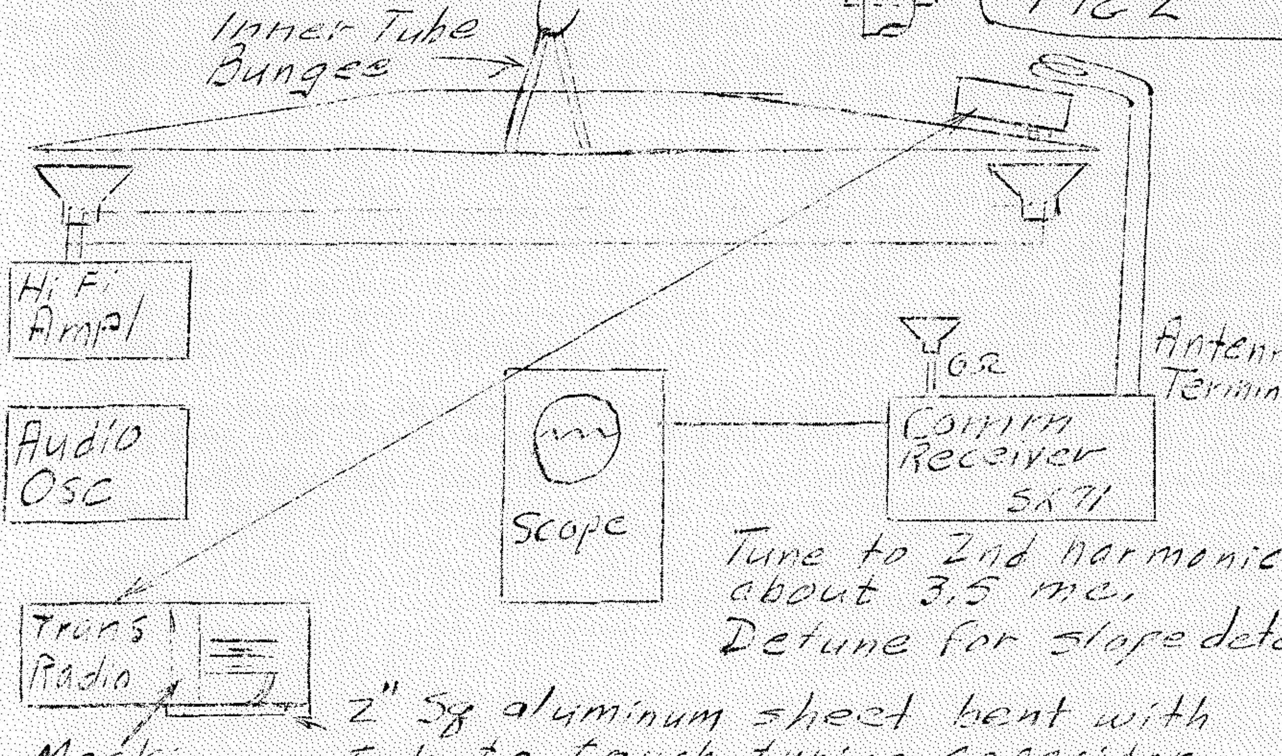

FIG 1. STATIC PROP SHAKE TEST RIG

76 is the original length in inches. The E refers to the airfoil shape which has basically an ellipticalcamber over the front part. M specifys the flange type. Designation for the flange are as follows:

- K - SAE1
- M - SAE2
- R - SAE3
- C - ARP502 (Cont and Frank Sport 4)

The next M is no longer used and has now been changed to a number specifying bolt diameter in 16ths of an inch (6 = 3/8" and 8 = 1/2"). Following the dash is a number indicating inches removed from original diameter and after the next dash is the pitch in inches.

Serial numbers also tell a story. Forgings for Sensenich propellers were made by both Alcoa and Kaiser. The early blanks made by Alcoa have no prefix to the serial number. The 74DM props with no prefix have a larger hole in the center. Later blanks made by Kaiser have a K prefix. Both have similar vibration characteristics however. Early model 76EM propellers have no suffix. They have a first mode second order and third mode tenth order resonance at 2250 rpm. When these were re-worked (and on all subsequent new 76EM propellers) the blade thickness was reduced 3% to lower this resonance to 2160 rpm and a K suffix was added to the serial number.

BILL COX FLYS - 419 Willow Lane, Baytown, Texas, 77520 - I now have 26 hours on #182, 20 hours of which was open cockpit. Most of this flying was done at 115 to 120 mph. The only ill effect I could note was a slight buffet in the rudder. I believe the average light plane pilot can probably transistion into the T-18 easier by leaving the canopy off the first few hours. Speed doesn't build up nearly so fast and it slows down easier. Also when open cockpit I would land 3 point very near stall speed. With the canopy, if I get too slow before touchdown, the tail wheel touches first and it will roll along aways before the main gear touches. I am still flying off a 2000' sod strip. I approach at 80 mph and ground roll with average 1200 to 1300 ft. with little breaking. Sunday evening it was cool and I made 2 landings to a full stop in 1000ft, same 80 mph approach, power off, 30° flaps and generous use of brakes. I have Rosenhan wheels and brakes on a standard gear. There is no tendency to nose up even on a full power run -up. These brakes will barely hold at full power. I still need to seal around the bottom of the canopy and fair the gear legs for a little more speed . At low altitude cruise is 145 IAS which is the same as a friend's 180 Cessna. Engine is O-290 D2 Lycoming, prop is Flottorp 67-67. All the following data was at 1280#, temp. 90° F at 50' field elevation. Cruise at 8000', 158 TAS (Density altitude 10,500), 2600 RPM 20" MP. Full bore at 200', 2950 rpm, 170 IAS. Rate of climb at 110 mph - 1400 FPM. Climb - 50' to 8000' in 8-1/2 minutes. Power off stall (clean) 62 mph., Oil cooler is 8 plate Corvair in front and below left front cyl - oil temp. 210F.

O-290-G CAMSHAFT - The July 1972 issue of the EAA Designee Bulletin warns about the use of O-290-D2 camshafts in O-290-G engines. It reports on phones conversations with Lycoming factory personnel. "One conversation, in particular, with the engineer responsible for the valve train stressed the dire results of mixing the hydraulic cam into a solid lifter system. The valve dynamics of the two systems are not compatible."

This should sound vaguely familar to you T-18 Newsletter readers since we have been warning aganist this for some time. The distressin thing is that people disregard our advice and often proudly tell about using a D2 cam "and the engine hasn't come apart yet.

That articlein SPORT AVIATION some time ago by the guy who advise people to use this cam has really caused problems. If you are using or converting a "G" engine, go back and read the T-18 Newsletter articl on this engine and take the advice seriously. To my knowledge the information in my articles is correct.

FUEL TANKS - There has been much talk about the porous material which can be put in fuel tanks to stop sloshing and for crash safety reasons. The FAA has just notified EAA in a hazzard in its use:

Gentlemen:

The following is furnished for amateur aircraft builders.

We have recieved a Malfunction and Defect report on "Safoam" material, manufactured by Firestone Tire and Rubber Company, Akron, Ohio, which was used in a fuel tank to prevent fuel slosh and spraying in case of impact.

The material had been installed for two years and was breaking down. It had become hard and brittle and was causing fuel stoppage problems. The aluminum tank containing the Safoam cellular material. The type of fuel carried in the affected tank was 80-octane gasoline.

Sincerely,
Paul E. Cannom
Chief, Flight Standards Div., GL-200"

JOHN THORP'S T-18 - On a recent flight test over a measured course at sea (ocean) level, John indicated 215 mph at 2850 rpm. His ground (sea) speed averaged out both ways at 209 mph so he is very happy with the performance. His prop is 68 x 35 which has a 1st mode resonance at 2875 rpm. Because Sensenich doesn't like to use props twisted to such a high pitch, John is considering going to the 72" light weight constant speed Hartzell prop used on other aircraft. Bill Eckel has one on his 180 T-18 and is averaging 195 on round trips

METAL TOOLS AND RIVETS - USAYCO, Air World, 8121 Jericho Turnpike, Garden City, L.I., N.Y., 11040 is a complete source for all aircraft sheet metal tools and rivets. Send for a free catalog. Also, anyone in the N.Y. City area can obtain sheet aluminum locally. 4 x 12 sheets of 2024-T3 x .025 alclad anodized are $12.50 in quantity of 4 or more and $15.00 single from: Joe Gertler, Raceway Equipment, 2650 Raymond Ave., Bronx, N.Y., 10461, phone 212-824-5796.

WOODEN PROPELLERS - Just visited with Ted Hendrickson, Rt. 3, Box 103, Snohomish, Wash., 98290 and enquired about his ability to supply wooden propellers for large 4-cylinder engeines. He has made several for the slower pushers (Breezy and Volmer) with no problems. One which he made for Bob Hamner's 125 hp T-18 had too much pitch and wasn't flown very long. It was also too much for LonEdvinsen's 150 hp T-18. Ted is now cutting it down in both width and pitch. I'll keep readers posted on progress. Ted made the three-blade prop which was on the Cessna 170 at Oshkosh this year. You should see the neat glueing press he uses. The movable part is activated by air pressure applied to a fire nose. The inflated nose applies perfectly even pressure.

NEW WOODEN PROPELLER DEVELOPMENT - As a result of Sensenich's recommending against twisting the 76EM blanks from the original 60" pitch to the approximately 85" pitch required for the O-360 engine, we are making the arrangements to develop a new wooden propeller for the O-360 engine. It would not be economically feasible to have a new metal blank made since the tooling would cost about $30,000. Ted Hendrich of Washington offered to build a wooden prop if someone would design one. When I asked John to design one, he said he was sitting there looking at the remains of a wooden propeller which had lasted just 20 minutes on a skyskooter. When it came apart it broke all but one member in the engine mount. He said "this reminds me that I don't know how to design a wooden propeller.

So, I asked Henry Rose of Sensenich if he would develope a prop and he agreed. John is sending him the specifications and he will quote a price for the developmental model. The prop will be tested on a 180 hp T-18. We will use money from the propeller test fund to pay for this development program. If this works out all right we will do the same for the O-320 and O-290 engines. He plans to use a very thin birch veneer for laminations which airforce tests have shown are superior in strength and stability.

PROPELLER FUND - To date we have collected a total of $962. for the propeller test fund. The Hartzell test costs amounted to only $671. After printing and mailing costs for the test reports, there is a balance of $178.82. Effective immediately, test reports on the Hartzell tests can be obtained from the T-18 Newsletter editor for $2.00. Those of you who contributed to this project are to be congratulated for helped make one of the most significant contributions to the safety of the homebuilt aircraft since the EAA movement began. Not only do we now have two flight tested metal propellers available for T-18s but as a result of these tests, we convinced Sensenich to produce a new 68" diameter metal propeller for homebuilders.

Also, as a result of all this, I was able to collect alot of information on the subject of propeller fatigue which I put into a long article which will be printed in the November issue of SPORT AVIATION. Dave Biermann, President of Hartzell, Henry Rose, Chief Engineer at Sensenich and John Thorp all helped edit the article. It not only tells the results of the flight tests but also includes information on how to do static vibration tests on a propeller and alot of other information which doesn't seem to be available anywhere except in the mind of two or three experts in the country.

LEGAL FUND - We have collected a total of $1275. for the legal fund. These things never seem to come to a definite conclusion, but it looked as though we can termiate solicitation of more money, at least for the present. The last action was a deposition where, as I understand it, John presented what would be the basis for his defence. There has been no new activity in the case for about one year and nothing is scheduled . It doesn't even seem human that a case can go hanging over someones head like this without resolution, but that is the way the legal system works. If nothing else is done, that will be the end of it.

If there is money remaining after legal expenses, John has requested that it be put in a T-18 research fund to be used for such things as the propeller program.

AILERON HINGES - Nearly everone has questions about the strength of the aileron hinges since the eyeball says they look too small. Service on 90 T-18's says otherwise, however, for there has been no problem with the hinge. The only concern is the rear spar. Several persons reported cracks at the bend before the extra stiffener was added. Whatever you do, don't add a third hinge, for this would cause binding during air loads. If you want to add unnecessary weight and strength just lengthen the hinge another segment.

HAM OPERATORS - George Lange, 2605 Boston Ave., Muskogee, Okla, 74401 would like to contact other builders who are ham radio operators.

CROSSOVER EXHAUST SYSTEMS - L.D. Sunderland- Why use a crossover exhaust? The answer is very simple; to increase engine efficiency. You see, an engine has a big job on it's hands not only in driving the load, but also in getting rid of all the hot exhaust gases. It must expend energy and thus do work to push the exhaust from the cylind and exhaust system. Anything which obstructs or resists the flow of exhaust gas from the cylinder causes the engine to waste more energy on "garbage disposal".

The resistance to the outflow of exhaust gas is called back-pressure. A fundamental rule of powerplant engineering states that the lower the backpressure , the higher the powerplant efficiency. When two consecutive firing cylinders port exhaust into a common pipe like on many early light planes such as the J-3 cub, the back-pressure is high. Why? Because the two exhaust pressure pulses occur in the pipe close to one another. There is then a long period with no pulses while the other two cylinders are dumping gases into their respective stack. Someone has found that in a four- cylinder four-cycle engine the highest engine efficiency results from manifolding the exhaust from pairs of cylinders such that the exhaust pulses are evenly spaced. If the firing order is 1-3-2-4then 1 and 2 would share a common stackand 3 and 4 would share the other. The only "flea in the ointment" is that these pairs are on opposite sides of the engine, hence, the need for crossover tubes. Strange as it may seem, this arrangement gives lower backpressure than individual stacks which port directly into the atmosphere.

You may have heard from your automobile hotrod friends that the length of an exhaust tube can be cut so as to tune it for maximum efficiency. This is true if the tube can be made sufficiently long. Standing pressure waves are set up in the tube & the tube length can be adjusted to minimize the back-pressure at the cylinder ports. This tuning on an auto is done by trial- and- error by starting with the longest tube practical and cutting it down until things get better. Since there usually isn't sufficent flexibility in selecting the length of an aircraft exhaust stack- or the desire to suffer the penalites of an extra long one- tuning is not normally practical.

The potential engine efficiency increase which can be realized by using a crossover system is perhaps on the order of 7%. The shape of tubing bends, dimensions and internal smoothness at weld joints, in a particular system will give some variation.

DESIGN DURABILITY- When two exhaust ports on opposite sides of an engine are connected by a long curved tube which then extends another two or three feet past the resulting welded joint, it makes for a pretty shaky structure. If the entire tube is fabricated out of one solid weldment, it is almost certain to develop fatigue cracks within a very short time. First, the whole engine shakes in the engine mounts causing the stack to whip back and forth perhaps as much as a half inch during starting and stopping so it cannot be reinforced by a support to the airframe. The stacks usually project several feet beyond the engine and attempts to support them to the engine usually result in broken supports within 10 or 15 hours due to vibration.

In addition to the motion of the entire engine structure, there is a surprising amount of motion of one cylinder head relative to the other. If you doubt this, observe what happens when a home-builder connects a cooling baffle rigidly from one head to the other. I is just a matter of time before cracks develope in the baffle. The baffle must be constructed in a way that permits relative motion between the parts attached to each head. Exhaust stacks must be made with the same kind of feature. That is why the airplane manufacturers place slip joints in the tubing between cylinders.

To solve the problems of supporting the long exhaust stack and raising it's resonant frequency above the engine operating range, they break the stack aft of the Y-joint and insert a ball joint. Then, since the stack is free to swivel, it can be attached to the airframe with a flexible mount.

Before the author installed both slip joints and ball joints in the crossover exhaust system of his T-18, during the first one hundred hours the exhaust tubes and various supports cracked at least a half dozen times. This experience has been repeated several times by others. Several times builders have proudly opened their cowlings to show how they succeeded in keeping their crossover system together with various supports made of brake lining or tubes but had to turn away with a red face when they found them broken loose. Without a large dose of luck both ball joints and slip joints are an absolute necessity in crossover systems.

Fabrication- For the average homebuilder- or even the old-time expert- locating the proper materials and fabricating a cross-ovdr exhaust system may be the most difficult task encountered in building an airplane. If you are fortunate enough to have some extra money, a complete system can be purchased ready made (from Thorp Engineering) but if you are the intrepid type who likes to make his own- and are hard up- here are some tips which will make your job easier.

Finding proper raw material is the first problem. There are three choices, use old tubing salvaged from other aircraft exhaust systems, buy new stainless tubing or use the ordinary automotive type. The latter is the least desirable from the standpoint of weight and durability but it is the cheapest, easist to fabricate and most readily available. It comes in a minimum wall thickness of .065" while the stainless tubing used for aircraft exhaust systems is .035" thick. This means the automotive tubing is twice as heavy. It is made of this heavier wall thickness to facilate bending without collapsing and creating wrinkles with the tubing benders found in muffler shops. These shops usually charge $1 per bend so a system can be bent up to your specifications or mock-up without too much sweat. The simpilest procedure is to have a single bend made in a number of short sections of tubing. These can later be cut to fit and welded in place on the engine. If you want to go to the trouble, make a mock-up from something convenient like ¼" steel rod as shown in Figure 2. A number of cardboard discs can be slid on to check for clearances throughout the system. Take the mock-up to the

(HELP,HELP!!!! John just received another bill from the lawyers for $600 so the Legal Fund is now in the hole. Contributions appreciated.
muffler shop and they might be able to bend the tubing in sections which will reduce the number of weld joints. You will find the mock-up a great time saver in any case when you try to figure out how to get all those tubes going the right direction without touching the oil pan, another tube or the cowling. Regarding durability, rust isn't too much of a problem because builders have reported good results with the high temperature paint available at automotive stores. The main reason for not using this tubing is the weight penalty.

The best exhaust tube material is stainless steel. Two types of stainless are available from most tube supply houses, 303 and 326. The 303 is about half as expensive as 326. Specifications advise that 303 stainless is subject to intergranular corrosion, which can cause cracking, when it is exposed to temperatures between 900 and 1,300°F. 326 is resistant to that type of corrosion. Many builders have used 303 in aircraft exhaust systems without problems, however. One source for stainless tubing is Tube Sales, 175 Tuboway, Forest Park, Georgia, 30050, 404-361 5050. It comes in 1.5, 1.75 and 1.875 OD (for 65 to 90, 115 to 160, and 180 hp Lycomings respectively for example). Order .055 wall thickness.

Now for the 64 dollar question, how do you form the thin wiall stainless? A trip to your friendly muffler shop will produce one sadly wrinkled up piece of scrap. Fill a section of tubing with sand and weld caps on the ends and the same result will be obtained. After much experimentation, I hit onto the solution. Cut an 18" section of tubing. Machine two 1.5 inch long aluminum plugs. Insert a plug in each end of the tube and drill two 0.25" holes through each plug and th tubing for bolts. In the end of one plug through-drill and tap a hole for a 5/16" coarse thread bolt. Now, install one plug with two bolts and fill the tube with dry sand. Hold the tube on something that vibrates alot like a grinder that is slightly out of balance. After several minutes the sand will pack down an inch or two. When it stops packing down, install the other plug and fill completely full through the open hole. Install the 5/16" bolt and head forthe muffler shop with some spare sand.

Just to make sure, when you arrive, remove the bolt and check the sand level. You will be surprised to find the level has lowered significantly due to the jiggling in the car, and more sand must be added. This is why it didn't work to weld the plugs in the tube. Now, insert the bender and presto! A nice bend with the desired radius and angle. A few more trips to the muffler shop and you will have enough bends to make up an entire exhaust system. Again, multiple bends can be made in one piece to reduce the number of trips but this is a complicated process and it is especially difficult to correct a mistake.

When you try to drill the second tube for the bolt holes , you will discover that a drill jig is needed. One easy way to make this is to find or make a sleeve which just slips over the tube. Small holes . can be put in the sleeve to act as locator holes. After the sleeve has been removed they can be opened up with a clearance drill for the 0.25" bolts . The drill jig should obviously be made <u>before</u> the holes are drilled in the aluminum plugs.

Slip joints can be fairly easily made. Just machine a die block from any steel bar as shown in Figure 3. Cut a piece of tubing 6" long being careful to make the ends square,and squeeze the die into it in a press. The proper die bevel angle and a sharp corner are necessary to get the tube to release from the die after forming. If it does stick, tap the side of the tube all around at the large end with a ball peen hammer and it will fall off. The expanded sleeve should be about 4" long.

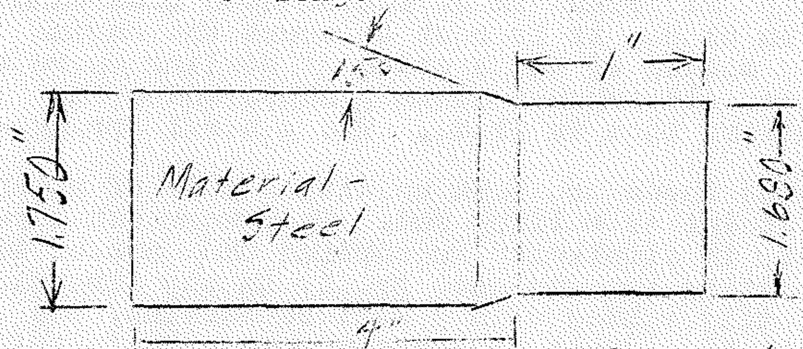

Fig 3 - Slip Joint Expander Die

It doesn't take much force to expand the thin stainless tubing. A hydraulic jack pressing against a post backed up by a beam in the basement will do nicely. Careful, don't tear the house down though. You can now go back and make a drill jig sleeve for the tube bending operation.

Ball joints are a bit more difficult to make. Finding them unavailable, the author made tooling to form on a hydropress the type Piper uses. Anyone needing 1.75" ball joints and slip joints can obtain them from him. Ralph Bowles, RD, Danby, N.Y., supplies the same type for 1.5" tubing. Oliver Smith, 83292 Fontana, Downey, Calif., 90241 makes and sells the type Mooney uses for 1.875" tubing.

Heat muffs can cause a problem if they are not properly designed. For instance, when the ends of the muff are made by welding flat discs onto the exhaust tube, they are sure to crack. A PA-11 we once had regularly developed cracks in the muff ends. The very best design is like the one used in the Aircoupe. The ends are formed like cones so the thermal gradients do not set up such high stresses. These ends can be formed with a solder bar over an aluminum die as shown in Figure 4. Material can be .015" stainless which is formed around the die and rivetted. The ends are then tack welded to the stack with three or four short welds, as shown in Figure 5. The muff jacket is made of .025" thick 2024-T3 aluminum.

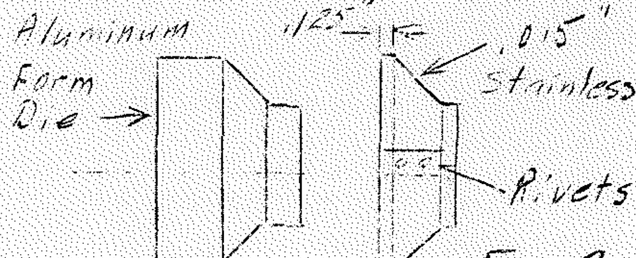

FIG 4

If you don't know how to weld aluminum, hose fittings can easily be put together from .015" stainless sheet and silver solder. (Use leftover .015" sheet from the firewall.) They are then rivetted to the aluminum jacket. The inlet for the carb heat muff can simply be rows of holes punched around the ends of the aluminum jacket. The total area of all inlet holes must exceed the area of the carburetor inlet. Outside air should be supplied as the inlet source for the cabin heat muff, however, to insure that engine compartment fumes are kept out.

When all the peices have been accumulated, you are ready to put the whole mess together. You will find a chrome cut-off wheel used in a table saw (available at Sears stores) will be of great assistance for cutting the tubing. It is extremely important to fit the stainless tubing very closely at all joints or you won't be able to tack it, much less make a good weld. Whereas you might cheat and fill up a gap greater than the required 1/16" maximum for 4130, you will find it highly desirable to keep all joints in stainless much less than this. To fit the tubing in place, it is best to mount the engine inverted on a bench with a mockup of the section of cowling where the two stacks must exit. Place old exhaust stack gaskets under the flange fittings before bolting them in place. The general arrangement is shown in Figure 5.

The spring clamp mounts shown are bent up with a pair of pliers from one length of 3/32" stainless welding rod. They work out perfectly and are the ultimate in simplicity supporting the ends of the exhaust stacks while permitting them to move freely in any direction.

Stainless is most readily welded with a Heliarc machine, but if you don't have one available, don't fret because the old faithful oxyacetylene rig can be used. Two gas welding techniques are feasible. With the proper flux and rod, stainless can be welded if a really generous amount of excess acetylene is used. You will find it easier to weld down hill and progress in steps, like in puddle welding although the bead may look more like a ghastly lump than a puddle. Be careful to keep the bead from sagging through or you will lose everything you gained in efficiency with the cross-over system. A second technique involves the use of 308-15 flux coated arc welding rod with the oxyacetylene torch. This does a superb job. Of course, if you are a novice welder, better get some help from an expert.

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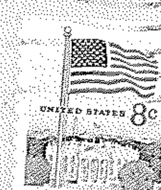

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