EXPANSION ENGINE POWERED MODEL AIRCRAFT.

CO_2 COMPRESSED AIR STEAM.

by BERTRAM POND

Second Edition

PRINTED IN THE UNITED STATES OF AMERICA.

PREFACE

The purpose of this book is to make available information regarding expansion engines & related model aircraft & equipment. Data from the 1800s to the latest state of the art are included. Some items are included for the historical value involved. Others are shown for novel features. A few are "what not to do" examples.
The drawings vary in delineation because many different people made them. With varying degrees of effort, an experienced modeler can duplicate many of these creations. I will have achieved a most important objective if you are encouraged to make similar equipment of your own design.

I am very grateful for the help of many people. The following is a list of just a few who have helped:- John Brown, Donald Burnham, William Cooksey, Carl Carlson, Tom Crompton, Gerhard Everwyn, James Fullarton, Bruce Grayling, Klaus Hammerschmidt, Jack Humphries, Alex Imrie, Donald Lockwood, Tom McCoy, Ron Moulton, Fritz Mueller, Lynn Pond, Danny Sheelds, Karl Speilmaker, Edmund Winter & Frank Zaic. Thanks so very much.

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Camm-"Model Airplanes"
"The Design of Model Airplanes
"Power Driven Model Aircraft"
Cavanaugh-"Model Airplanes & Their Engines"
Hertz-"Model Aircraft Spacecraft & Rockets"
Ross-"Sterling Cycle Engines"
Ott-"Model Airplanes, Building & Flying"
Roughley-"Aeronautical Work of Hargrave"
Waring-"Airscrews for the Aeromodeller"
Zahm-"Aerial Navigation"

Periodicals

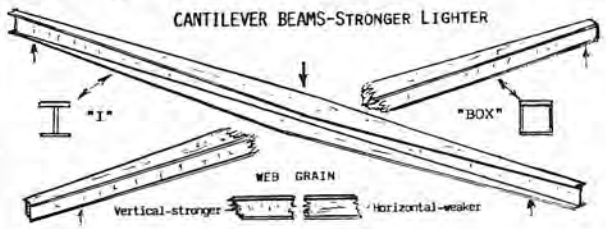
Aerial Age
Aeromodeller
Aeronautics
Engine Collectors' Journal
Model Engineer & Practical Electrician
Model Maker
Popular Aviation

Designs for Minimum Weight & Reduced Stresses.

First of all, every modeler should have an accurate scale, grams preferred. The companion is a loose leaf book for keeping records of your model weights & all other data regarding your models. This is the best way to keep track of all of the numerous details.

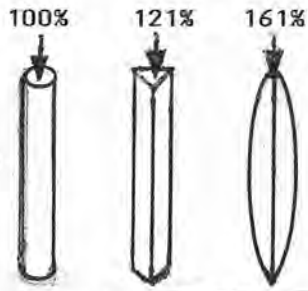
Just listing the weight does not tell you how to make the lightest & the strongest structure. It does enable you to compare different ways of fabricating a model or part. The data on beams in that old engineering handbook does not give all of the answers either. If you pick a beam in the handbook, the book has the formulas for that beam, but is that the best beam shape? Wings do fold in flight all too frequently. We beef up our stuctures often where it is not needed. This makes model heavier, stressing the wing all the more.

A "Think Tank" determined that lightest beams of uniform height have bottom & top flanges widest at greatest stress point(s) & taper uniformly to zero at the tips.



See sketches at left. Webs or sides should have wood grain run vertical to resist horizontal shear. The top compression flange should be made slightly thicker than bottom. The box is better in torsion than the I beam. By using this taper beam, models will be lighter & stronger.

Another "Think Tank" structure is the column for taking end compression loads. It is the round column-you think. You think wrong. The same amount of material in a column of the same length with an equilateral triangular section is a whopping 21% stronger. Then the "Think Tank" tells us that if this triangular section column is tapered parabolically & using the same amount of material the column or strut will take a 61% larger load before buckling. The wooden streamlined struts on the old biplanes were tapered for strength & lightness. The triangular shape would be very useful for fuselage longerons since they are columns between each vertical member. Then the vertical members can be triangular as well to save even more weight. The covering materials can be used to stiffen the parts & make them resist buckling. If silk is used for the covering material, run the threads lengthwise on the bottom of the wing surface for the tensile strength. On the top surface run the threads in a diagonal 45° path to assist in the torsional stiffness of the wing. Wet the silk while covering to get the tightest job. Then for the lightest best looking dope job, do not use a brush on the silk. In order to obtain a light weight finish use the USA/UK "meniscus" doping procedure.



When the silk is fully dry, wet a clean soft cloth with dope & drag the cloth by one end over the surface of the silk. As you drag the dope saturated cloth along, add more dope to the cloth as needed-not to the silk. This procedure fills the pores of the silk without drops of dope soaking through to the inside of the silk. Practice with a scrap piece first. See SAM 35 #3 Yearbook. Light weight wheels made with 'foamcore' are described elsewhere in this book. They can contribute to making a light model even lighter.

For lightest weight models, cap strips on the ribs may not be needed if the ribs are cemented to the covering. This can be done by brushing a coat of 50% model cement & 50% thinner to the edges of the ribs. The dope will soften this cement & stick the rib & tissue together. Long thin ribs can be zig-zag braced spanwise from rib to rib with the lightest monofilament fishing line or sewing filament. The filaments should be fixed to the ribs with a touch of adhesive. See Bottle Baby plan. If you brace the wing panels with monofilament to central pylons, the wing structure can be made very much lighter than if an unbraced cantilever wing had been used. In the most common case of wings with uniform chord, a single set of bracing filaments attached at 2/3 span produces the least wing stresses. In this case, the "Think Tank" type of wing beams would be widest at this 2/3 span location.

Propellers for Expansion Engine Powered Model Aircraft.

'taint gonna fly without a good prop! So propellers for expansion models should be designed so as to provide the best possible performance. With the very limited supply of energy on board, what type of propeller should we use? We want the largest diameter propeller & the best pitch to diameter ratio which the engine can drive in order that our model will travel the highest & longest possible time. This means that the first initial thrust should be as high as possible, up to at least 1/4 to 1/3 of the total weight of the model. This is similar to the performance of good rubber driven models. You can catch thermals with your COMPRESSED AIR expansion engine type models. Some have found thermals & been lost. So it is suggested that you fit your expansion engine ships with effective dethermalizers. Basically, a propeller is one or more airfoil shaped wings or blades being driven in a circular, rather than a straight path. The lift of the blades becomes "thrust" & changes the circular path into a spiral track.

The book "Airscrews for the Aeromodeller" by R. H. Warring is a very good reference work. It has formulae, charts, graphs along with understandable explanations taking the mystery out of propeller design. All modelers should have this book. Among other things, the book makes a good case for the pusher propeller. The propeller behind the fuselage is not blasting a slip stream back along the body with related drag. The book points out that the inner 25% of the blade radius produces no useful thrust. Therefore a streamlined support for the outer 75% of the blade radius would be better.

About 85% of the work done by a propeller is accomplished by the outer 50% of the blade radius. So it is logical to design our propellers with these proven facts in mind. Put most of the blade out where the work is done!

Theoretically, a one bladed propeller should be the most efficient. However I believe that the drag of the counterbalance & support plus its weight, which is not contributing other than for balancing the single blade, cancel any aerodynamic advantage of the single blade propeller. The two bladed propeller is considered the best to use for expansion engine powered models.

The pitch to diameter ratio which will be found to be most efficient is at least 1-1/2 to 1. For example, a 14" diameter propeller should have a geometric pitch of 21" or even an inch or two more, if the model is well streamlined.

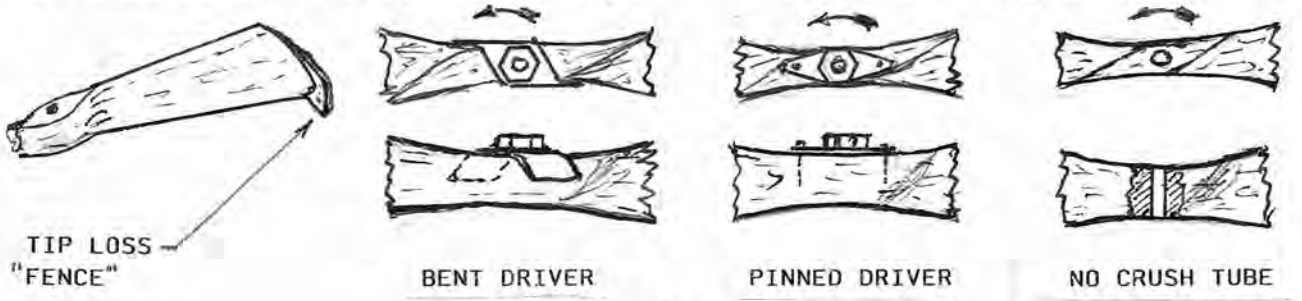
On full sized aircraft, wing tip losses have been studied & several types of wing tips are in use to reduce these tip losses. Wing tip losses in free flight models may not be corrected with these tips because of stability problems. We can cement a little triangular piece on the tips of our propeller blades to reduce the tip losses there. This tip piece also protects the blade tips & can be replaced easily when damaged without disturbing the rest of the blade.

Regarding free wheeling, most expansion engines will free wheel after the pressure is exhausted. In other words, free wheeling is usually automatic.

Folding propellers are used sometimes on expansion engine planes to reduce air resistance for better glide & to reduce the chances of damage to the tractor propeller & engine. The shift of the center of gravity when a propeller folds is negligible & seldom requires that it be compensated for.

It is good practice to have the expansion engine run in the direction which tends to tighten the nut which retains the propeller on the shaft. In order to keep the shaft from turning faster than the propeller, a strip of metal can be soldered to the nut. The strip may be either bent or pinned to the hub of the propeller.

Another bit of advice is the suggestion that an aluminum tube which fits the shaft closely be fitted through the propeller hub to prevent the nut from crushing the balsa.



VALVES, GAGE-(1)Filler; (2)Throttle; (3)Relief; (4)Pressure regulating;(5) Pressure gage.

1-FILLER VALVE. Common bicycle & automobile tire valves & cores are used for air filler valves. Auto tire shops discard the old valve stems when installing new tires. Reduce weight by thinning wall & cutting length to fit short type valve cores. Leave threads for pump attachment. Length overall should be about 5/8" The core & valve should weigh about .1 ounce. Filler valve should be accessible for attaching & easy use of pump fittings. The valve should be mounted securely in order to withstand the stress of the pumping operations.

Another excellent filler valve from England uses a free floating plastic plug for a valve core. They are light in weight. Due to different thread size, they require a different adapter on the pump hose.

Dust caps on the air valves are not used because of the slight extra weight.

2-THROTTLE VALVE. On-off valve would be a better name since the valve is not touched once the model is airborn. These valves are generally needle valves. 1/4 turn cock valves are fine if they do not leak & if they are light in weight. The cock valves should turn easily too. Fish tank valves are available in either type. They should be made as light as possible without interfering with their function. The needle valves usually have a packing around the stem. The packing & nut can be removed to save weight. Use a thick hard grease on the threads to avoid excessive leakage. Open cock valves have practically no more air resistance than a straight tube. Therefore a light weight air tight cock valve is better than a needle valve if you can find or make a good one. Lockwood seals needle valves with Teflon packing.

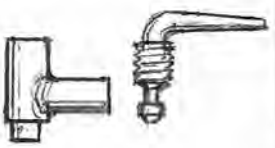
3-RELIEF VALVE. Relief or safety valves are seldom used. They are usually a spring loaded plunger which opens when the set pressure is reached thus preventing over stressing of the air tank. They may be made, as shown in the sketch, by using a plunger which seals the hole in the end of the bicycle valve body. The spring is fitted freely over the plunger stem. Once that you have a spring which has the proper force to match the air pressure over the hole in the bottom, slight adjusting in relief pressure is possible by screwing the nut (from a valve core) in or out as needed. In principle, the relief valve operates just like a filler valve only in the reverse direction & with a higher opening pressure. These valves will weigh about .2 ounce. The pressure at which the relief valve will open may be calculated by dividing the spring force by the area of the hole in the end of the body. Care must be used in order to prevent the spring from binding with the stem & the inside of the body because any friction would cause irregular shifts in the pressure at which the valve opens & closes.

4-PRESSURE REGULATING VALVE. At first consideration, a pressure regulating valve would seem to be desirable. They are seldom used for various reasons. First, they have weight. Then some energy is lost through the valve. Most important is the fact, that like rubber models, the first burst of energy without any regulator causes the model to climb freely at its maximum rate. Since torque & power vary as the 4th & 5th power of the diameter respectively, the proper size of propeller is its own pressure regulator & no other device should be used.

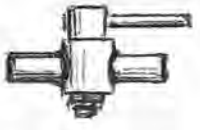
5-PRESSURE GAGE. The weight of air born pressure gages on a compressed air model is prohibitive. It is important to know the pressure in the air tank(s). The gage can be a separate hand operated gage. It is better to have the gage in the air hose or as a built in part of the pump. The gage may be watched closely & with less stress on the filler fitting on the tank. The elasticity of plastic tanks is sufficient so that an approximate pressure can be obtained by observing a band of material fastened loosly around the tank. See Bottle Baby #2 drawing & writeup for details. However an accurate gage on the pump is the better & more accurate method.



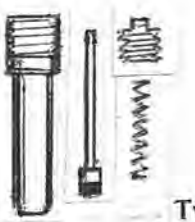
Filler Valve

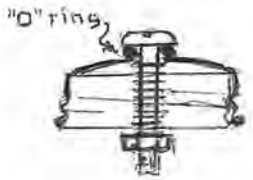


Throttle Valve



Cock Valve





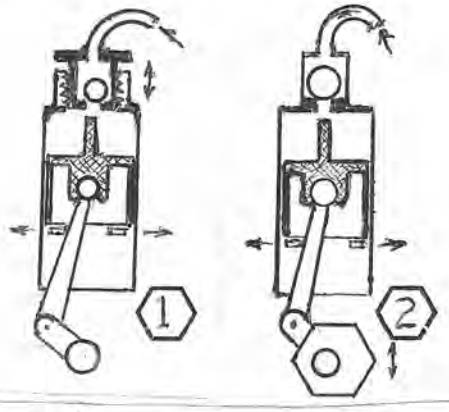
Two Relief Valves

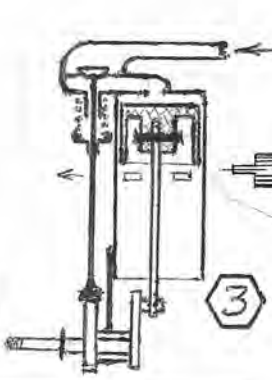
Types of Valves Used in Expansion Engines

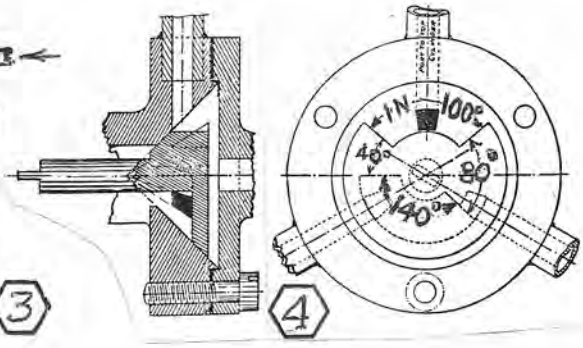
In order for expansion engines to run properly, the steam, air, CO_2 or other gasses must be directed to & from the cylinders in an orderly fashion by some form of valve. The valves should operate at the best timing schedule.
For model aircraft, the expansion engine valve must be -A- light in weight, -B-leak resistant, -C-durable, -D- opened to large area quickly & cut off sharply, -E- moved with a minimum of energy loss, -F-opened to avoid any back pressure & close in time to allow for some expansion of the gas already admitted.
Valves found in various expansion engines meet these requirements in varying degrees. Obviously the best valves should make the best possible flights. Let us examine a group of valves. Refer to the numbered schematic drawings.

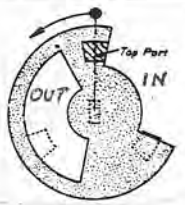
1. This one is a ball valve in which an extension on the piston lifts a trapped ball to admit a gas, usually CO_2, into the cylinder. See the CO_2 engine listing for the names of ball valve engines. The height which the ball is raised off of its seat is the throttle control. Some of the ways of doing this are, -A- screw the cylinder head in or out, -B- screw the whole cylinder in or out, -C- move the crankshaft up or down. The ball setting is rather critical. A little more lift provides a lot more power but less motor run. Conversely, less ball lift reduces power & increases the duration. In -A- & -B- above, the small tubes are disturbed & may be damaged. In -C- above, the tubes are not disturbed. The crankshaft bearing hole is off of the center of its bushing. By rotating the bushing, the whole assembly of crankshaft & rod with piston is moved with respect to the ball.
2. The -C- type throttle in the Telco engine is the second type of arrangement. This type can not be adjusted easily while the engine is running since the adjusting nut hexagon is directly behind the propeller.
3. Poppet valves are used very little. They do operate with very little wasted air volume. The poppet valves require cams, push rods, & often rocker arms. These items add weight & complication of adjustment. Springs are generally required too.
4. This miter cone type of valve can be made to function quite well if accurately made. Pressure pushes the cone against its recess with considerable force. This results in loss of energy & wear. The leakage paths are short so that a little wear may soon cause air loss.
5. The rotary disc valve resembles the disc valve in model gasoline engines & the timing is the same as in the miter cone valve in 4 above.
6. Your grandfather & great grandfather should remember the very popular Weeden toy steam engine with its vertical boiler & that fascinating cylinder which oscillated back & forth at each revolution of the crankshaft. The connecting rod & piston were rigidly joined so that the centerline of the cylinder always pointed at the crankpin. A spring is required to hold the cylinder against the valve face to prevent leakage. Two holes are in the valve face & one mating hole is in the cylinder. The hole in the valve face which is connected to the pressure determines the direction of rotation. The other hole acts as the exhaust. Model aircraft engines have been built with single cylinders & with 2 or 3 cylinders. There is no means of adjusting the timing. The valve holes may be filed to a rectangular or square shape for quicker feed & exhaust for more efficiency & power. The top & bottom edges of the piston or pistons tend to wear as the piston rocks the cylinder back & forth.
7. Rather than oscillating the whole cylinder, several engines have been made which oscillate just the valve. This requires flexible tubes between the valve & the supply. The friction of the moving valve & the energy lost in flexing the tubes at each revolution make this type of valve unsuitable for model aircraft engines.
8. The cylindrical valve mounted at the top side of the cylinder controls the supply at the point of use with very little waste volume. This type of valve is better for use in larger engines like the Cetonia where weight & friction are less vital.
9. The flat slide valve is similar to the cylindrical valve in location. In this valve, the pressure holds the valve against its face creating some extra friction. It is seldom used for small expansion engines.

Expansion Engine Valves for Controlling the Media-Gas, Air, CO_2 or Steam.

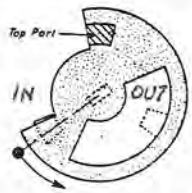




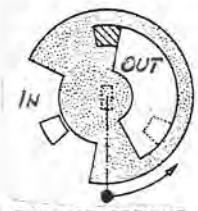




ADMISSION OPENING
(At top of stroke)



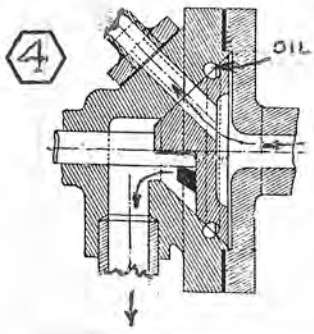
ADMISSION CLOSED
(Cut off at 66⅔ of stroke)

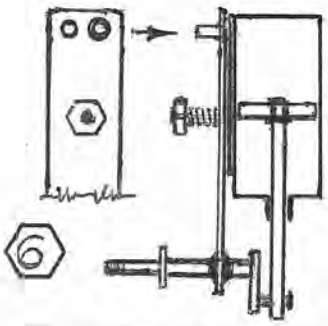


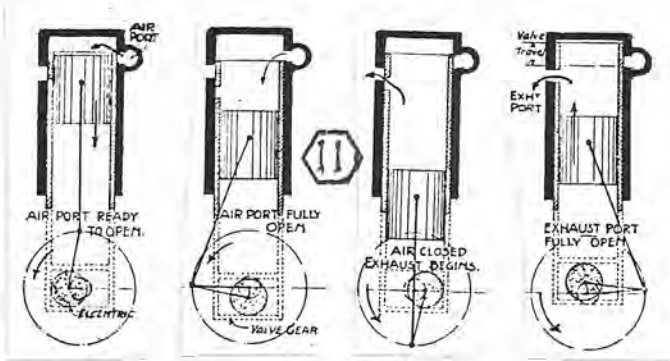
EXHAUST OPENING
(At bottom of stroke)

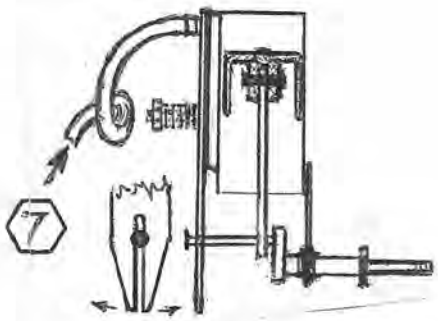


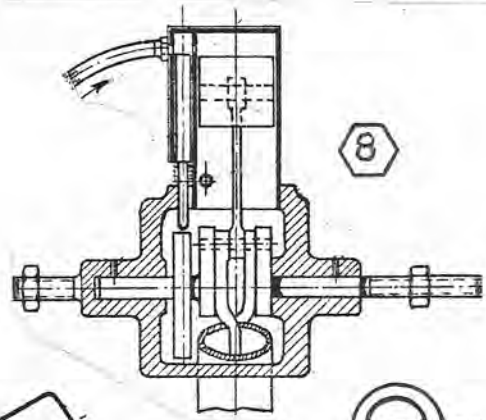
EXHAUST CLOSED
(At 80% of up stroke)

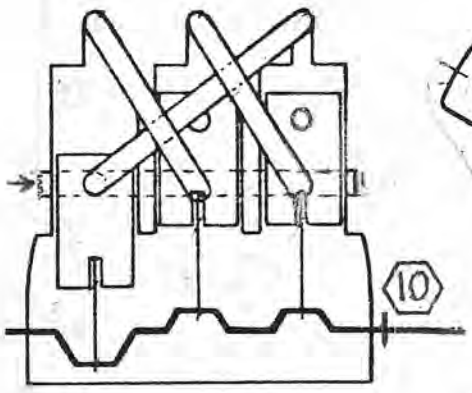


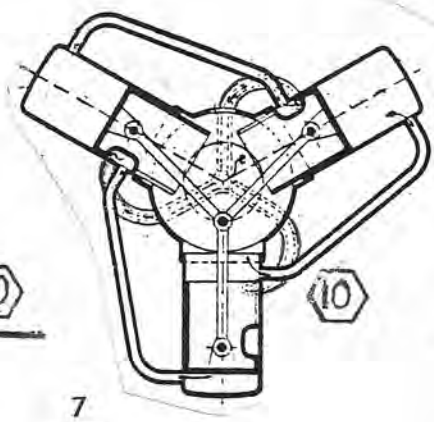


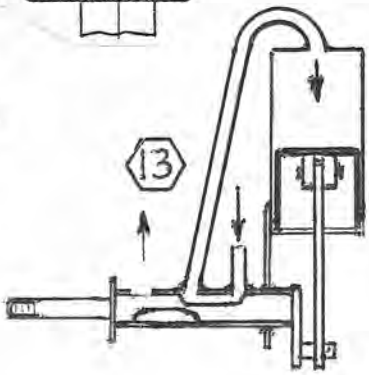




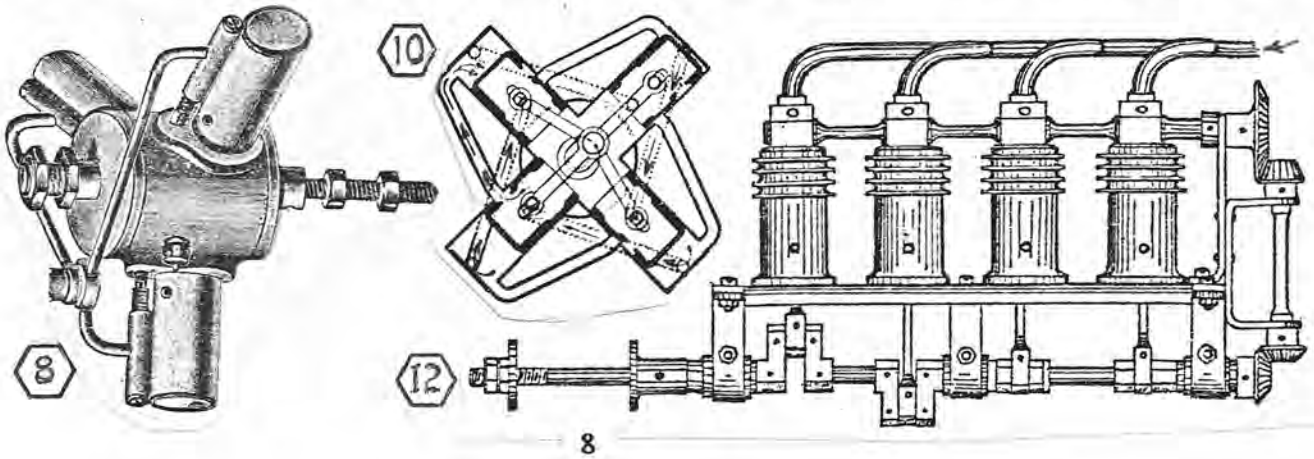








10. The use of one piston to act as a valve for the piston in an adjacent cylinder has been used in several expansion engines. The Pause 3-in-line expansion engine is of this type. Number one cylinder & piston feed number two cylinder. Number two cylinder feeds number three. Number three feeds number one all in turn. The Bing Autoplan three cylinder radial engine is valved in the same manner. In the Pause, the hollow wrist pin is apparently the valve passage. In the Bing, an inside piston with a pocket or "blister" serves as the valve passage to connect the pressure source to the next or adjacent cylinder. The Cole 4 cylinder radial engine has the same type of valving. The amount of piping required makes these engines look like spaghetti. The pressure hole is covered much of the time. The pressure over the area of this hole results in a force which pushes the piston against the opposite side of the cylinder. This increases friction & produces uneven wear in all of this type of engine valving.
11. I know of but one sleeve valve expansion engine intended for model aircraft use. The cylinder in which the piston operates is also the valve. It is moved up & down by an eccentric on the crankshaft. The large areas of sliding surfaces & the doubling of the weight of the cylinder rule out this type of valve for my model aircraft engines.
12. The overhead rotary shaft type of valve is used on the Butterworth expansion engine. It is a 4-in-line engine. Alignment of all four overhead valves in the separately mounted cylinders would seem to be a difficult chore. The media is fed at the point of use without waste but the weight of this type of valving, along with the added friction loss of the drive, make it undesirable for model aircraft.
13. The use of the small diameter crankshaft & its bearing sleeve as the valve is the most common method used in expansion engines which actually fly model aircraft. The cutouts & holes actually reduce the weight. In engines with two or more cylinders the pressure forces are fairly well balanced. The friction is the same as though the valve were elsewhere on the engine so no friction forces have been added. The small radius of the shaft make the friction torque quite small compared to the cone, disc & sleeve type valving. A long shaft which is lapped to the bearing sleeve does not allow any appreciable leakage. Tapered shafts can be fitted closely & adjusted axially for wear to prolong useful life. An air chamber around the outside of the bearing improves these shaft type valves by feeding the air or gas from close by rather than from the more distant tank. In the three cylinder radial expansion engine two cylinders should be arranged to receive air at the same time. The shaft valve groove should have a slight overlap. This not only assures sure starting but it also makes the engine more powerful because two cylinders are always working at one time. The Whirlwind expansion engine, when used as a tractor, provides thrust in the direction which makes a rotary seal to prevent high pressure seepage, similar to water pump & refrigeration rotary seals.
As a further refinement of the straight shaft valve, feeding the medium into a hollow shaft between two in-line cylinders traps the high pressure gas so that there is no place to go but to be valved into the cylinders. The small rectangular windows reduce the "curtain" area for leakage to the smallest possible. This is the very best type of valve that I have found for expansion engines. It is a little tedious to make but it is simple enough. See the Walking Beam engine.
Are there any other types of valves for expansion engines? Yes there are many. However most all are not suitable for our very light weight model aircraft applications.



Gasses for Expansion Engines.

Expansion engines may be operated with a variety of gasses & vapors. Some gasses are more suitable than others. Different physical & chemical properties as well as availability & cost enter into the picture. Years ago hydrogen was tried as a gas for an expansion engine. It leaked quite severely due to its thin viscosity so that even with less air pressure better flights were obtained. The explosiveness of H_2 gas makes it rather undesireable as well. Strangely, helium has a viscosity a bit higher than air. Where He is available it would be better than air to use. It does weigh only about 1/7th of the weight of air in addition to less inherent leakage. The model would climb faster due to less weight & motor run would be longer due to less leakage.

When a gas flows in a very thin film between a piston & cylinder wall or between a valve shaft & sleeve, this small film is considered to be laminar & viscous. If this path is extremely thin & the path from pressure zone to atmosphere is of some fair length the leakage is negligible. In leakage formula

$$q' = (13.54 \times 10^{6}) \times \frac{\Delta P \times d \times C^{3}}{\mu \times L}$$

q' the quantity of gas in cubic inches per minute varies directly as the pressure difference on each side of the piston. It also varies directly as the diameter of the piston. Leakage is reduced directly in proportion to the length of the piston & the viscosity of the gas, μ.

The most important factor is the diametral clearance between the piston & the wall of the cylinder. Here the cube of the clearance tells very quickly whether the gas leakage will be excessive or not. Any clearance over .001 inch starts to make the leakage excessive. Below .001 clearance leakage is so small that it can be neglected.

	Viscosity in centipoises (μ) @ 68°F (20°C)	Specific Gravity
Air	.01829	1.000
Argon	.02217	1.377
CO_2	.01480	1.516
Helium	.01941	.138
Neon	.03111	.690
Hydrogen	.00874	.069

Note the higher viscosity of helium than air. Helium is often available at indoor meets for the filling of steering balloons. It would not be too expensive for use as a gas to drive an expansion engine. Normally however it should be available to all contestants who wish to use it in their models.

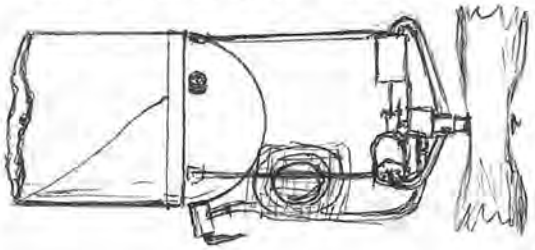
Hydrogen is given, not because it is suggested, but to compare its viscosity & weight with other gasses in the list.

However air will still be the gas which most contests & contestants will be using.

A very little leakage is unavoidable as well as desirable. Air is a super lubricant, so a slight leakage lubricates piston & cylinder. Oil lubrication before each flight is essential for best results. The key to long flights is having plenty of air, very close piston & cylinder diametral clearances & a good stable flying model. Clearance between valve sleeve bearing & shaft should also be very close. Failure to keep these clearances very small has been the down fall of many expansion engines in the past.

As gasses expand the temperature is reduced. Tanks become cool to the touch. On a humid day, moisture will collect on the outside of a tank after a flight or test run. This drop in temperature is not as great as calculations would indicate due to fact that some heat is absorbed from the air by all surfaces which are cooler than the air temperature. This is a type of passive heat recovery.

More substantial amounts of heat may be added by other more positive means. One such means is quite simple & has been used with some fair success. It consists of a loop in the air feed pipe from the tank to the motor. The loop contains a piece of nitrate soaked cardboard which had been dried. It is ignited & a screen slipped over the loop of tube & the glowing cardboard to prevent loss of the glowing coal which could otherwise start a fire if dropped from the model. The weight of this device is quite small but well worth the effort.



Some Additional Methods of Enhancing Duration of Expansion Engines.

In the CO_2 section the addition of heat is described to prevent the formation of "dry ice". This allowed the engine to run as it was supposed to for the best possible duration. For the early CO_2, hot water was used because water has the highest specific heat of most any common substances.

For COMPRESSED AIR, however, the weight of the water tank & water would be a bit prohibitive. The air does not form ice in the pipes but it does cool off due to the expansion. As it is cooled the volume for flying becomes less & less. There are several things that we could do to put a little heat back into the air & improve duration.

A passive type of heat enhancement which was used on the life support systems of the astronauts could be adopted quite easily to our compressed air tanks. The method is simply to pick up some of the heat from the tank shell itself! The air pipe from the tank to the engine is made long enough to wrap around the tank in intimate contact with the tank surface. As the tanks surface picks up heat from the air outside, the air inside of the pipe is absorbing heat from the tank shell as well as the outside air. Since it worked on the space equipment it certainly would be a simple way to increase duration of our COMPRESSED AIR models easily & with a very minimum of added weight.

Another more interesting & sophisticated method of adding heat to the air using the heat of fusion of a substance has been suggested. Heat of fusion is the heat required to melt a substance without there being any change in temperature. This is worth consideration. A small amount of a substance like glycerol which melts at 64.4°F. [20°C.] requires 47.4 calories per gram to melt without changing its temperature. Schematically, a heat exchanger is shown at the right. The glycerol, or other suitable substance, would be melted just before the start of the flight, perhaps to a little higher than the temperature of glycerols melting point. Then the air passing through the air pipe to the motor would be maintained closely at this melting/freezing temperature until all of the glycerol was frozen. This should be lighter in weight than the hot water tank arrangement. The material could be used over & over again. There must be other materials which melt/freeze in a useful temperature range! Who will be the first to try the heat of fusion enhancer?



Schematic- Heat of fusion gadget

Another similar type of enhancer is the heat of solution. Some substances give off heat as they dissolve. The common calcium chloride road dust stopper & ice melter gives off heat as it dissolves. It is cheap too. A few drops of water & some calcium chloride or other 'exothermal' material will warm the air as it passes through the heat exchanger on its way to the engine.

Combining one of these air "enhancers" with an engine which is most efficient, such as the walking beam engine, should produce the top winning combination.



Schematic-Heat of solution device

Over the years, most all COMPRESSED AIR engines have been overly powerful and therefore required large air tanks which were out of proportion to the rest of the model aircraft. Only recently has the fact that even the smallest displacement engines are amply powerful to fly models of conventional size. This permits the tanks to be of more nearly proper proportions to provide very good endurance. In other words, the small COMPRESSED AIR engines can be said to enhance the duration of model aircraft.

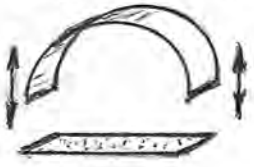
A Few Numbers Concerning Pressure Vessels for Expansion Engines.

A. What pressure will burst a thin spherical tank?
B. What pressure will burst a thin cylindrical tank?
C. How much overlap is required on thin tanks which are soldered or cemented?
Stop if you know the answers. If not read on!

A. Any way that one looks at a thin walled sphere with pressure inside, the force trying to burst it is the pressure over the greatest cross sectional area - P x A- or $P \times D^2 \times \pi/4$. What is trying to prevent this bursting? The area of the thin material in the largest circumference of the sphere times its stress in tension, $A \times S_t \times t$ or $\pi \times D \times t \times S_t$ is the opposing force. $P \times D^2 \times \pi/4 = t \times D \times \pi \times S_t$; or $\frac{PD}{4} = t \times S_t$
So if we need to know any of these factors they may be calculated as follows:

$P = \frac{4tS_t}{D}$; $D = \frac{4tS_t}{P}$; $S_t = \frac{PD}{4t}$; & $t = \frac{PD}{4S_t}$ Always allow a margin on the safe side.

B. A cylinder with a hemispherical end would perhaps burst the ends by the same numbers as the sphere. However the numbers for the cylindrical part may give a different result if we look at the forces which would split or tear the cylinder in a lengthwise direction.



To make it simple, let us consider just one unit of length. Again the pressure to blow our tank lengthwise is P x A or P x 1 x D. See the diagram. The resisting forces are the 2 unit strips of material or 2 x t x S_t x 1. To find unknowns:

$P = \frac{2tS_t}{D}$; $D = \frac{2tS_t}{P}$; $S_t = \frac{DP}{2t}$; & $t = \frac{DP}{2S_t}$

Comparing the sphere & the cylinder formulae, the cylinder is the weaker of the two. For the same thickness of material the sphere is two times as strong as the cylinder. Also the cylinder would burst or tear more or less in an axial or lengthwise direction. Cylindrical tanks with hemispherical ends have ends thicker than the cylinder. This is true because of difficulties of making & using a very thin half ball. However the conical ends may be made of the same material thickness as the cylindrical sheet. Cones with an angle at the apex of about 90° would be light in weight when compared with the thicker half ball ends. However cones should be no thinner than the cylinder material.

C. Do we have to worry about the overlap of soldered & cemented joints? If the soldering or cementing is secure & well done it should not separate. Even if the cement or solder is only 1/50 of the strength of the cylinder the lap would only need to be 50 times the thickness of the cylinder. If the cylinder was .004 thick the lap would only need to be 50 x .004 or .2 wide. Using 1/4" width of lap is common practice in the making of brass tanks from hard spring stock. This allows a fair safety margin. You must always test the tanks at pressures higher than they will be used. Although the elasticity of tanks is not evident by just looking at them, measuring the diameters at two different pressures using a micrometer makes the difference in the diameters quite evident.

The elasticity of plastic tanks is greater than that of brass tanks. An average 3 liter tank tested stretches about 1/16" in circumference for each 30 pounds pressure or about 3/16" at 90 psi. See the circumferential gage described with the "Bottle Baby" model. If a tank does not return fully to its original diameter upon release of the pressure, it has been stretched permanently & should not be used. Two liter plastic tanks, because of their smaller diameter, do not stretch as much as the three liter tanks. This also allows a slightly higher pressure to be used in two liter tanks.

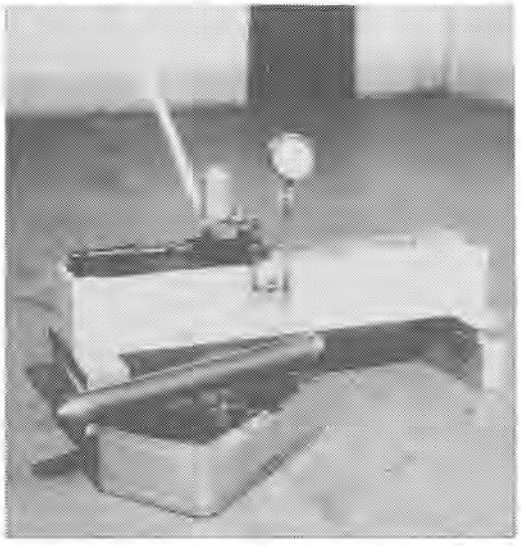
Double length of joints on aluminum over lap of 1/2" is suggested for use along with an especially good adhering cement & mating surface preparation.

Corrosion, scratches, wrinkles, fatigue- all may occur to a tank. Therefore at any sign of defect the tank should be retested behind a suitable barrier & tested at least once each season.

Formulae for thick walled vessels are different than for our thin wall tanks & such formulae should not be used.

Pressure Testing of Air Reservoirs for COMPRESSED AIR Models

Testing of air reservoirs is essential in the interests of performance & safety. Not every one has a Stanley Steamer injection pump such as illustrated with which to test air tanks hydraulically.



Air tank was filled with water. Then it was connected to test rig as shown. With 2 check valves, a 600 pound gage & a water feed container, burst tests were made. For want of a Stanley Steam car injection pump, a similar test rig may be improvised with a hydraulic jack. With hydraulic rig, a squirt of water is only indication of a failure of vessel under test. Use of this rig showed that 1/16" solder lap of end caps to cylinder was adequate since failure occurred elsewhere. Logically it may be concluded that axial center rod or wire used by Pavely & others is not necessary for retaining end caps.

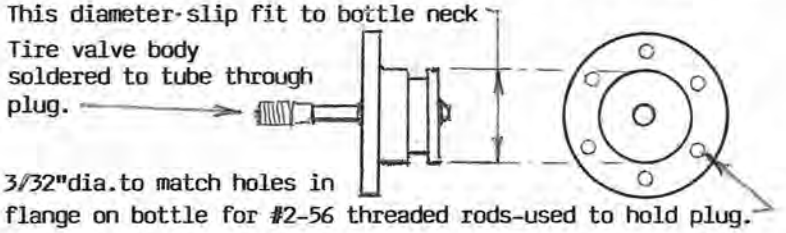
Pressure testing with air has quite a different end result, & requires that adequate precautions be taken to avoid any damage to property or people from violently air propelled pieces of test tank when failure occurs. Covering test piece with a rug may confine fragments but prevents observation of deformations prior to failure. Placing test vessel behind a barrier where it can be observed with safety glasses through a hole permits noting any abnormalities prior to actual bursting.

Tanks should always be tested to a higher pressure than they will be subjected to in flying a model.

For air pressure testing, pressure may be obtained using air pumps which operate on 12 volts from cigarette lighter socket in an automobile. Such pumps are available from automobile supply stores. Obtain highest rating pump available. A 200 psi. pump rating should be adequate to burst test most plastic tanks. Of course these electric pumps are ideal for inflating your air tanks (& tires too) if you find that hand pumping is too fatiguing. 12 volt air pumps are available with ratings higher (to 220 psi) & lower too. Higher rating pumps do pump faster but must be watched more closely in order that pressure wanted is not exceeded. Be sure to obtain a pump with a pressure gage so that you can know when to stop the pump. Some pumps have pressure limiters but these devices do not indicate any approach to limiting pressure which dial gages do. A switch at pump is desirable. A good well charged battery is suggested with these electric pumps. Drain on batteries is not very much but pumping a large number of tanks could discharge a battery sufficiently that it would no longer start your automobile. Some people carry a duplicate battery fully charged to flying site to avoid this problem. A trickle charger at home keeps duplicate battery at top charge ready at all times for testing of flying. In an emergency spare battery will start your car too.

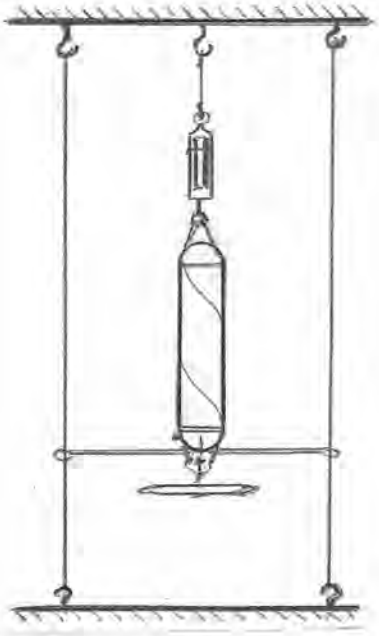
After air testing to some chosen pressure, check all seams for leaks. Immersing in water will reveal most leaks easily. Some leaks are difficult to locate this way. A superfine leak may not be noticed for several reasons. Leak may be so fine that it appears like a very fine spider web for a short distance & then it disappears by air dissolving in water. If such a leak is on opposite side of tank no bubbles would be evident to observer. Take ample time to try & locate any of these "spider web" like leaks.

Sketched at right is removable test plug for testing plastic tanks. Steel, iron or brass may be used. Groove must be more shallow than diameter of "O" seal & wider.



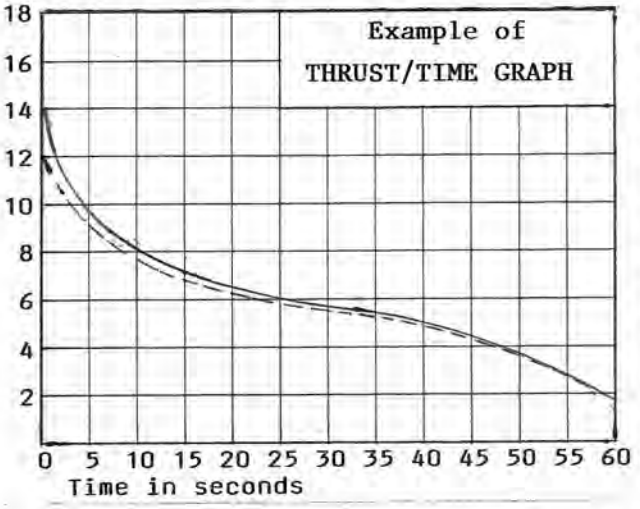
THRUST TESTING

What makes a powered model go? THRUST!
For combustion engines, THRUST is generally uniform. However in compressed air models, THRUST is variable with maximum at start. Then as pressure in reservoir gradually diminishes, so does THRUST. This is quite similar to rubber models in which as rubber unwinds thrust becomes less.
In order to be able to design COMPRESSED AIR models with a high degree of success, knowing THRUST characteristics of our power plant is most essential. However if you design by trial & error, this THRUST testing is not for you.
Statistics from experience give us a rule-of-thumb which is quite useful. A reasonably well designed model should R.O.G.-take off & fly-if initial THRUST is at least 25% of total flying weight. Also if a model glides say 30 feet while sinking 3 feet, it should also maintain level flight under power if THRUST is 1/10th of model weight approximately. So THRUST can tell much about what a model should be. Since THRUST varies with time, THRUST at various times of motor run would be most helpful. In fact if we have THRUST & TIME graph we can predict whether or not a model will fly & how well. We will know what maximum weight of model should be, namely 4 times maximum initial THRUST. If we can build lighter so that total model weight is 3 times THRUST we may be able to get model up into a bit of 'lift' or thermal. All of this can be planned before model is made by just knowing THRUST of power plant.
For example, if total power plant weighs 12 ounces & THRUST initially is 5 ounces then total weight of model can be as much as 4 times 5 or 20 ounces. Subtracting 12 from 20 leaves 8 ounces for our model. Now how can we best determine this THRUST data for our powerplant? Fortunately "The Model Engineer & Practical Electrician" (English) of April 21 1932 described several novel test rigs designed to help obtain this important THRUST data for a COMPRESSED AIR power plant. One most easily constructed rig consists of a suspended spring scale as shown at left. Our power plant is hung from this scale with propeller down. A rod is fixed in a horizontal position near lower end of our power plant. Loops or hooks in each end of this rod loosley engage two taut vertical guiding wires to prevent torque from rotating our power plant in opposite direction to rotation of propeller.



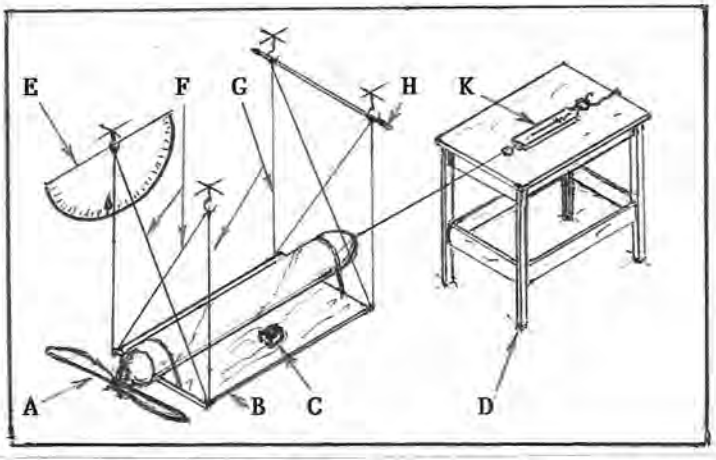
Though this rig is easy to set up, we must know power plant weight both with full pressure & with no pressure because weight of air in tank must be subtracted from scale reading for test results to be accurate. Note dotted line on time-THRUST graph. Beginning & end points of this curve are known & curve closely follows solid line & joins it at right or end of test run. On left, difference is actual weight of air at full pressure. Note, airflow should not be obstructed any more than it would be in actual model plane. See next page for graph. Hooks could be put in doorway, shelf or ceiling.
Another type of Model Engineer test rig is a horizontal arrangement of power plant & scale. In this set-up, weight of air does not enter into results because air weight or gravity acts vertically & THRUST occurs 90° from vertical or horizontal. This horizontal rigging can

be used in several ways to measure THRUST: A- by a scale; B- by angle of swing supports; C-by either A or B above but with a steady flow of air through a flexible tube from an adjustable pressure air supply separate from rig. See schematic diagram below. In testing with a scale, with our power plant horizontal, scale must be in line with axis of motor & propeller, & platform supports are vertical at start of test run. Effect of slight angling of strings will have negligible effect on accuracy of results.



If swing angle is used as in B, no scale is required. Some tendency of platform to oscillate or swing may occur. Holding swing platform at approximate starting angle as air valve is opened for test run may help this problem. Also adding a bit of weight to platform reduces period of swing & makes test more manageable.

PROTRACTOR ANGLE	WEIGHT MULTIPLIER
5°	.0875
10°	.1736
15°	.2680
20°	.3640
25°	.4663
30°	.5774
35°	.7002
40°	.8391
45°	1.0000



An assistant may be needed in conducting tests using any of these rig arrangements to help record data. In using protractor angle of swing-B method-total weight of platform multiplied by "WEIGHT MULTIPLIER" at each angle is THRUST. Plot should be identical no matter which method is used.

For more accurate results, especially if you do not have a helper, a steady-state test may be run. You will need an air compressor & a pressure gage mounted near power plant. Air tube from compressor to platform MUST coil around a cross rod at one of supports in order to prevent air tube from interfering with platform motion. By adjusting compressor air pressure to any pressure desired, you are able to obtain THRUST by either scale or swing-angle methods. Be sure to oil motor regularly.

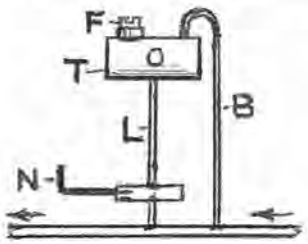
Model Engineer had another THRUST test rig using a weight over a pulley with power plant on a small 4 wheel cart on an inclined board. Take your choice of methods or devise one of your own; but do know THRUST characteristics of your power plant. It can be difference between success & failure!

[Key to schematic-A=power plant; B=swinging platform; C=optional weight; D=table E=protractor for measuring swing angle; F=diagonal anti-sway strings; G=equal length support strings; H=optional air tube support rod; K=ounce scale.]

LUBRICATION OF EXPANSION ENGINES.

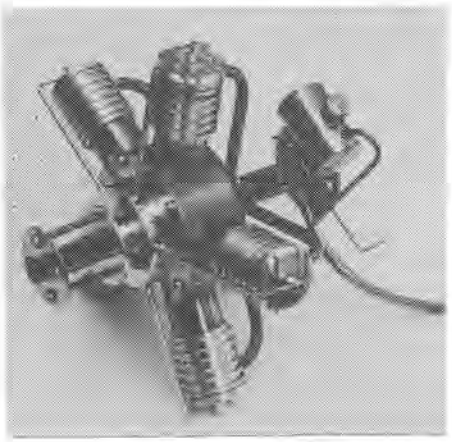
Oil serves a two fold purpose in expansion engines. In addition to reducing friction, oil reduces air leakage past pistons & valving. Oil however is blown away in time increasing friction & wear & air loss.

In steam engine applications lubrication of cylinder is often accomplished by a balanced pressure oiling system. Steam tends to wash away oil so it must be replaced. Diagram at left shows basic arrangement of balanced pressure oiling system. Oil is put in tank "T" through small airtight screw fitting "F". By-pass tube "B" allows pressure of air above oil in tank to be same as it is below oil "O". Needle "N" in oil feed line "L" (a model gas engine needle valve may be used) adjusts gravity flow rate of oil. Tank should be filled before each use. This device works with other gasses as well as steam.



Due to weight, it is seldom used for compressed air applications. During extensive testing or for flying models with extra large reservoirs, balanced pressure oiling system may be useful. Normally, oiling compressed air engines before each flight is adequate. If throttle is needle type, remove needle but do not drop it in tall grass! Then while turning propeller shaft in normal direction, add oil through needle hole. A dozen drops more or less will do. Replace needle & you are ready to make another run. Oiling external surfaces such as exposed cylinder walls, wrist pins & crank throw pin should be done too.

What oil should be used? Very thin oils would soon wash or blow away. Very thick or viscous oils waste energy because they act like a brake. Expansion of air in an engine cools oil so oils which thicken upon cooling are not suitable. Best oils to use are thin but adhere to surfaces & do not thicken upon cooling. Regular compressed air engine oil is available & gives best results. Otherwise use lightest winter grade motor oil in your close fitted air engines. Worn or loose engines require either heavier oils or replacement of worn parts.



Treating engines with substances which tend to reduce friction by coating surfaces is very desirable. Moly-sulphide, Teflon & graphite may be used. Lower friction is maintained for longer periods of time after their use. Simply coat surfaces & run engine for a short time. Engine pictured at left is a very beautiful 5 cylinder rotary engine built by Walt Winberg. This engine is equipped with a pressure balanced oiling system for providing a flow of oil over a long period of operation. Tank with filler screw cap is in upper right of picture. Pressure balancing tube running from tank to air feed pipe is visible. Oil flow by gravity is controlled by model gas engine throttle needle valve visible between by-pass & feed pipes.

Cup washers on pistons saturated with oil are used sometimes for lubrication; however friction drag due to air pressure forcing cups against cylinder walls probably cancels all advantage. In addition, cups require more piston clearance with cylinder heads & waste this volume of air with each piston stroke. Strings saturated with oil in piston grooves similar to piston rings have been used. These should work satisfactorily when pistons have thick enough walls to accomodate them. String should not exert pressure or drag on cylinder walls. Strange as it may seem slight air leakage past pistons & main shaft type air valves reduce friction energy losses sufficiently to more than compensate for energy in air lost. Air has extremely low friction & air bearings are used for many low friction applications. Lap fits waste very little energy.

Pumps for COMPRESSED AIR Models

Pumps come in a variety of types. Foot operated toggle pumps usually have too large a bore & too short stroke to fulfill C.A. requirements. This leaves hand & electric pumps & large portable pressurized tanks.

To be suitable, a hand pump should have a small bore & a long stroke & a handle which is comfortable. The bore is best if 1-1/4" diameter or less. A stroke of 20" or more is desirable. The handle of the pump should be at least 8" long & strong enough to take your full weight on the downstroke. Pumps with a check valve in the base are helpful if they do what they are supposed to do. These valves are supposed to keep the pressurized air in the hose from flowing backwards on the up stroke of the plunger. Hand pumps with a built-in pressure gage are convenient. If the hose is even slightly elastic it should be replaced. Keep the plunger cup washer clean & oiled for best results. Hand pumping technique requires that full strokes be used. Keep handle of the pump close to the body & thighs so that near the bottom of the stroke, where it is most important, the whole weight of the body can be applied in order to force that slug of highly compressed air into the tank by the plunger hitting the bottom. A bit of extra effort at the end of the stroke may be required to complete the stroke at maximum pressure. A heavy person can usually pump to a higher pressure than a lighter person. Sometimes two or more people take turns in order to get the pressure desired. The old 2 stage or 3 stage multi-barrel compound pumps are seldom worth the effort.

Electrically operated pumps are available in many pressure ratings. These pumps are for 12 volt use from the cigarette lighter socket in the automobile. Such pumps should have a pressure rating of at least 150 psi. or higher. Some have an adjustable and a helpful pressure control in the hose. Others have an auxiliary tire valve where pressure can be checked with a tire gage. The better pumps have dial type pressure gages. They are well worth the few dollars difference in cost. Most all have a short hose & a long electric cord with a switch located near the pump. Prices vary from $20.00 to about $50.00 in current catalogs. If your car battery is old, you may wish to run the engine while using the pump so that you will not need a jump-start to get going when you are through flying for the day. I have a duplicate car battery which I keep fully charged. I use this battery for running my electric air pumps. Incidentally the air pump & spare battery come in handy for automobile emergencies.

The "free air" at most service stations is too low pressure to be useful for C.A. & service stations are seldom adjacent to the flying site.

Supplying air from a large tank at the flying field would be an ideal way if the tank pressure could be maintained constant at 150 psi. or pressure ruled for the day.

Never use oxygen, hydrogen or other high pressure sources in filling C.A. tanks. Oxygen in the presence of oils may create spontaneous combustion, even explosions. Hydrogen is explosive & its properties are mentioned elsewhere. Carbon dioxide combines with moisture to form a mildly corrosive acid which can damage metals. Pressures of 1,000 to 2,000 psi. are hazardous to work with & should not be tried! Moisture in the form of the humidity in the air enters the tanks & creates conditions for internal corrosion of metal tanks. Corrosion does not affect the plastic tanks. Do not use a tank which has not been pressure tested to a higher pressure than will be used for flying. Retest at least each season for more safe fun. Remove tank from model for testing. Wrinkled or otherwise damaged air tanks should not be used without being retested .

Use eye shields when testing.

These electric pumps are recommended for the older modelers. The pumps save a lot of work especially on a hot day.



The New Plastic Air Tank for COMPRESSED AIR Model Aircraft.

Tatin's steel tank, Pavely's brass tanks & Crompton & Winberg's aluminum beverage can air tanks seemed to be the last word in tanks until Jack Humphries came along with his plastic tanks. Jack was working in a plastic factory & saw some boys sending up rockets to a surprisingly high altitude. He found that they were filling plastic bottles about 1/3 full of water. Then they would stopper the bottles & pump air into them until the cork blew out & the bottle took off.

This prompted Jack to test a plastic bottle at work during lunch break. He placed a bottle connected to the shop air line under some boards in one room. Then from around the corner in another room, he turned on the air slowly & watched the gage while awaiting the "big bang". The gage had crept up to the maximum shop pressure yet there was no 'bang'. Jack cautiously inspected the air line for kinks. There were none. Then, "biting the bullet", he felt under the boards & pressed on the tank. It had not burst & had taken the full shop air pressure. It was hard as a rock to the touch.

So Jack, who is a modeler, built a big 8 foot wing span model of the ship pictured at the bottom of the Ott products page. Jack modified the plan slightly in order to accommodate 3 plastic bottles in place of the original single brass tank. This model was pictured in Aeromodeller & in Model Builder.

Other modelers, including your author, began testing plastic bottles with the idea of using them for air tanks in model aircraft. Using a duplicate car battery which I keep charged with a trickle charger, I checked them with an electric pump. If the bottle expands under pressure, does it return to the original size when the air is released? A circumferential belt of Mylar or some other thin non stretch material, held snugly around the tank with a small rubber band, was used to observe this growth. For example, the 3 liter (183 cubic inch) bottles expanded about 1/16" for each 30 psi. At 90 psi the marks on the overlapping belt showed that the bottle had stretched 3/16" but returned to its original size upon release of pressure.

Since the bottles vary slightly, you must test your own or purchase tested bottles in order to operate safely. Metal tanks expand & contract under pressure in the same manner as the plastic tanks. However the expansion is less evident. A caliper or micrometer will show this expansion quite easily. Metal tanks should be tested too.

Next, I tried a burst test on the 122 cubic inch size. My test confirmed the high pressure capability of these plastic containers. Do not test indoors because of the noise & the dust raised. I tested by placing the tank inside of a trash can. Then I attached the air pump fitting to the bottle through a spare car wheel which was leaned against the trash can. This worked fine except that the noise sounded like a trench mortar round.

See the tabulation of air tank weights. This table shows most clearly that the plastic tanks weigh about 50% of the weight of brass & beverage can tanks per a unit volume of air. As a result of these tests, I built two models for the SAM Champs, Bottle Baby #1 & Bottle Baby #2 as a back up ship. At Madera the #1 ship was damaged in a windy launch attempt. Bottle Baby #2 made a nice r.o.g. flight to win the COMPRESSED AIR event. See drawing of the model.

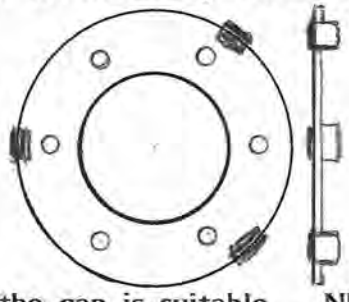
Plastic tanks do not corrode. Brass tanks do corrode sometimes internally where it is not visible. A few DON'TS may be helpful!

DON'T use any tank that has not been tested. See section on testing.
DON'T wind wire or other material around the tank. This does not increase rating.
DON'T ever apply heat to the plastic. The fumes are extremely toxic.
DON'T join plastic tanks on their major diameters. It does not work well.
DON'T be distracted while pumping with an electric pump. Watch the gage!
DON'T store any tank with air valve closed. Barometer changes can wrinkle tank.
DON'T support plastic tanks rigidly on major diameters. Use a resilient padding.
DON'T forget to thank Jack Humphries if you win with a tested plastic tank!

Making Plastic Air Tanks for Expansion Engine Powered Model Aircraft.

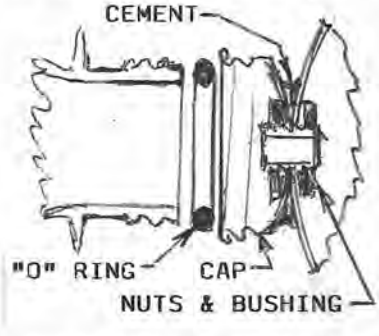
Actually the air tanks are all ready made. All that you have to do is to be sure that the bottles are suitable & then assemble the cap, valves & engine safely. The bottles come in a variety of sizes & shapes. The proper shapes of bottles are those with a hemispherical bottom concealed inside of a base resembling a NACA cowling. Bottle sizes available are 61, 91-1/2 (a new size from Canada), 122, 137-1/2 (available in England only so far) & 183 cubic inches. In liters, the sizes are 1, 1-1/2, 2, 2-1/4 & 3. From personal experience, the English bottles seem to be more inconsistent in wall thickness than the same bottles made in the USA. This is a special reason why all bottles should be tested for suitability for use as a pressure vessel. If the bottle has no thin places in the cylindrical portion or bad scratches, it should be a candidate for testing. Minor imperfections in the end sections are less important because the stresses in the hemi-spherical ends are only half of the stress present in the cylindrical portion.

That bottom piece is stuck on with 3 or 4 small globs of a soft cement. Some hot water may help soften the cement. However if the base will not come off easily, it may be cut & pulled off in pieces. The label cement & the base cement may be removed later when there is pressure in the tank. Acetone slowly dissolves the cement without harm to the bottle. You will find 2 thread sizes on the necks of bottles. The large size occurs on the 183 cubic inch bottles, but a few English bottles have the small thread. All of the rest seem to have the small thread. Most, but not all, bottles have a ring flange. The ring can be drilled for lightness & for attaching model components. A simple drill fixture may be made from a washer with a hole which barely fits over the bottle thread. Spring clothes pins will help to hold the jig while drilling. Run the drill at a slow speed so that it will not heat up the plastic. 3/32" holes will take # 2-56 screws which are ideal for holding parts. See the sketch of the drill jig at the left.



If you plan to mount the engine to the cap, you will need caps which can be soldered to. Caps which are flat will not work. However a very slight rounding of the cap is suitable. NEVER mount the crosswise tube in the center of the cap. The crosswise tube with the filler & throttle valve should be mounted close to one edge of the cap & soldered securely. The engine may be mounted on the tank centerline or off of the centerline so that the motor crankshaft may be removed for servicing. Also, the motor may be mounted away from the tank. The best way to mount the engine on the cap is by means of the air pipe. Cut & bend the air pipe to suit. When the motor is in the desired position with thrust line direction as desired, then you can cut & fit 1/8" or 3/32" tubes with the ends flattened & bent to fit; & solder them in place.

For remote mounting of the motor, plastic tubing is preferred to brass. Just wire the tubing in place with a twisted wire. If two or more tanks are to be used, the plastic tubing is easier than trying to join tanks. You will need a "Y" fitting to connect the multiple tanks.



Optional separable type of joint for the plastic bottles as air tanks.

In the event that you may wish to join 2 or MORE plastic bottles so that they may be separated, the sketch at the left is an alternate to the permanent method shown on the insert twin tank plan. The bottles must be screwed very tightly against the "O" seal. Silicone grease may help to seal any leaks. If not you can lose the removable feature & epoxy the cap to the bottle after cleaning off the silicone grease. The weight of the two types of bottle joints is the same since a cap has to be used in either case. The permanent method requires a cap on the opposite end. This makes the weight equal nominally. Pehaps you can devise other ways to join these plastic bottles for use as air tanks.

Comments on the Adhesive Bonding of Metal to Metal.

The reliability of adhesive bonding is a well established fact in the aircraft manufacturing industry. Adhesive bonding is not something which was dreamed up for joining beverage cans in order to make COMPRESSED AIR tanks for use in flying model aircraft. One of the uses in the aircraft industry is that of joining the upper & lower surfaces where they meet at the trailing edges of wings, flaps, ailerons & the like. These comments have been gleaned from military specifications on the bonding & testing of adhesive joints. Some comments were taken from an article in the magazine Machine Design by an engineer with the Hughes Aircraft company.

1. The total tensile strength of an adhesive bonded joint is directly proportional to the width of the joint. In the case of aluminum beverage cans, the strength is proportional to the circumference of the cans.

2. The tensile strength of short joints is proportional to the axial length of the joint.

3. In longer axial joints, the tensile strength does not increase quite as fast as the length of the joint. This is more evident in the thinner materials than with thicker stock.

4. This disproportionate effect is due to the elasticity of the materials.

5. The materials being bonded should have equal strength in all directions, that is, the materials should be "isotropic".

6. Joint strength depends upon the type of adhesive & the care used in following faithfully all of the steps in the bonding process.

7. Short joints normally rupture in the adhesive.

8. Long joints usually rupture in the metal.

9. Stresses should never exceed the elastic limits of either the metal or the adhesive.

10. Good technical adhesives come with instructions which must be followed very carefully for best results.

11. The lap joints in beverage can tanks must be round.

12. The center lines of all cans in one tank must be in one line.

13. In order to protect adhesive assembled tanks, & any other tanks, any supports contacting the cylindrical surfaces should be padded with a resilient material. This is essential because of the elasticity of the tank materials.

14. Any type of external winding or other reinforcement should not be used because such treatment on any tanks does not do what it would seem to do.

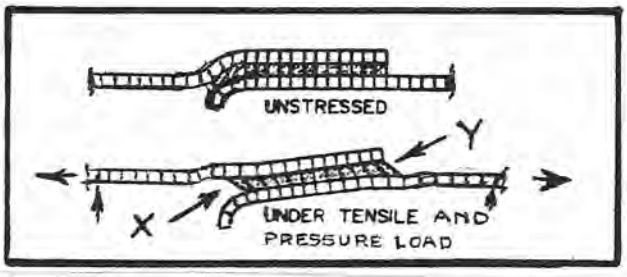
15. Nothing should be cemented or bonded to any of the cylindrical portion of any tank.

16. All tanks, including adhesive bonded tanks, should be tested safely before use.

17. These comments should help you to understand adhesive bonding of metals. for tanks as well as other metal objects.

ALUMINUM BEVERAGE CAN COMPRESSED AIR TANKS.

Walter Winberg from Canada & Tom Crompton from England experimented with this interesting type of air tank for COMPRESSED AIR model airplanes. Obviously they were seeking a tank which was better than existing designs. Various sizes of cans exist. Diameters of 2.46" , 2.60" & 3.31" are sizes of cans known to exist in U.S.A. Lengths also vary. Ordinarily in order to make a lightest tank, longer cans would be used. In order to make a specific length as closely as possible, mixed lengths of same diameter could be employed. Apparently all aluminum cans have a thin internal coating to protect aluminum from any corrosive actions of whatever liquids are introduced therein. Proper removal of this coating on mating internal surfaces is especially important for good bonding. Mating external surfaces must also be free of enamels, paints or whatever coating exists. It is not necessary to remove coatings from entire can surfaces-only mating surfaces. If solvent removal works as it does on some coatings a small amount of weight may be saved but it is negligible. Besides name of product on can may get you a sponsor! Complete removal of coatings is not sufficient for a good bond. Surfaces must have high polish or smooth surface removed to give "tooth" for bonding medium to hold on to. A wrap of masking tape will assist in confining "toothing" or fine sanding operation to area desired so that 'sponsors' advertisement will show neatly. Internal 'tooth' operation length can be controlled easily by guiding sand paper on edge of can. Use caution because edge of can is SHARP! Internal "tooth" should be done only after can has been expanded to a close fit with mating can. Otherwise expanding operation would smoothen "tooth". Only a very slight roughness is needed to provide adhesive shear strength in excess of requirement.
Fits of cans after expansion must be close. Loose fits promote voids in adhesive layer with resulting weakness of joint & probable air leak.



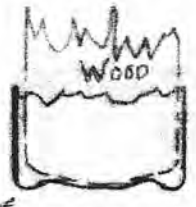
Also oil, fingerprints & any other contaminants will weaken joint. To get a good joint, mating areas must be cleaned with a pure type of solvent such as acetone & MEK. Adhesive must be tough, strong yet not brittle. Since aluminum does expand slightly under pressure, due to elasticity, a single thickness on each side of lap expands double amount of lap area. A tendency of outer layer to separate from inner layer at "X" requires that adhesive process be most carefully performed. At point "Y" there is no problem since inner layer is being pressed against outer layer so that there is no tendency for layers to peel or separate. Using a low shear strength for adhesive, a length of lap of 3/8" on smaller diameter cans & 1/2" on larger cans should prove more than adequate with good adhesive. To be on the safe side, if you have any doubt regarding adhesive, make lap 1/8" longer than noted above. Industrial structural adhesive such as 3M Scotch-Weld epoxy is preferred over hobby store epoxies. Follow instructions provided with adhesive closely.
Also follow suggestions on sketch sheet. Leave a bead to stiffen lap joints & prevent bending of adhesive joints. Mount air connection in center of ends. Never mount air connection on cylindrical portion of cans. This would make an unsymetrical stress condition which would be a weak point & undesireable. Assemble with adhesive "buttered" generously on both mating surfaces. Start engagement of cans so that you can look at bead. Bead must have epoxy fillet covering joint at all times. In like manner outer edge of joint must be fully covered with epoxy as cans are worked together to amount of full overlap. When fully engaged, salvage epoxy bead from inside & outside to use on next joint by scraping with dull tool. If your epoxy has a work life of an hour you have more than enough time. Align joints in a corner or vee trough & allow to cure.

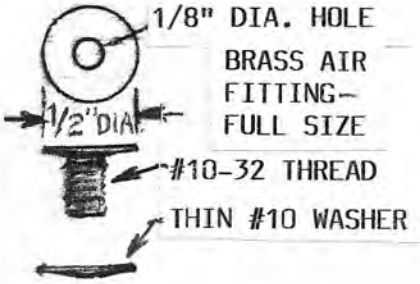
SKETCHES-MAKING ALUMINUM TANKS FOR COMPRESSED AIR MODELS



"CHUG-A-LUG"



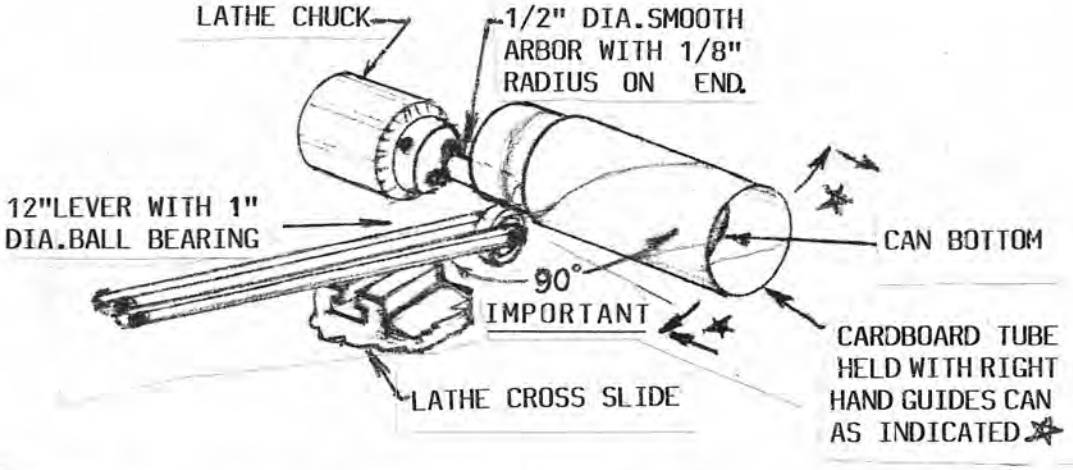


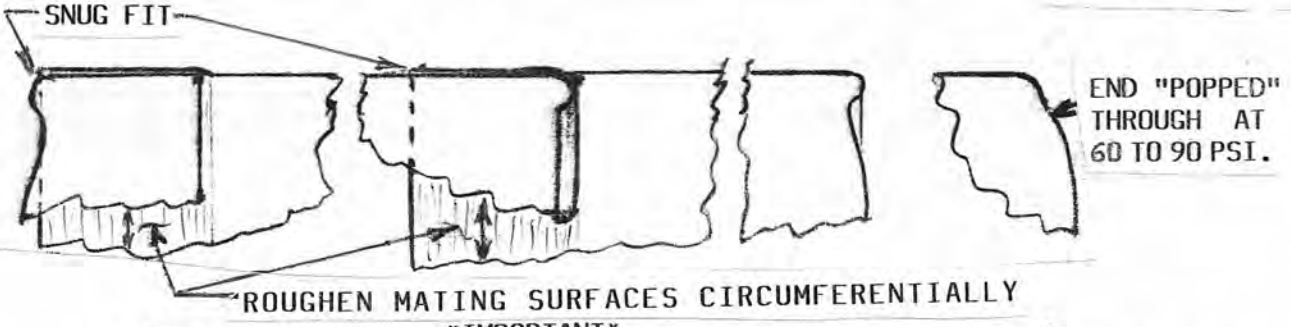


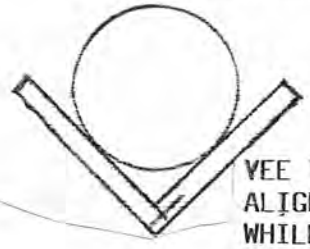


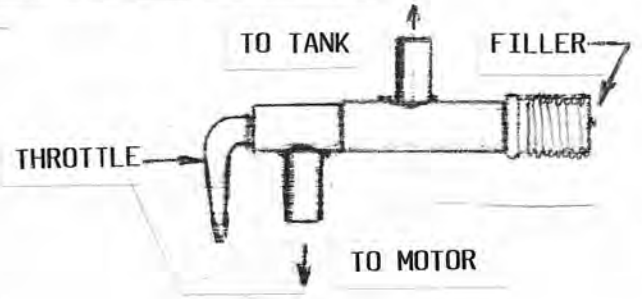


#10-32 NUT ALUMINUM



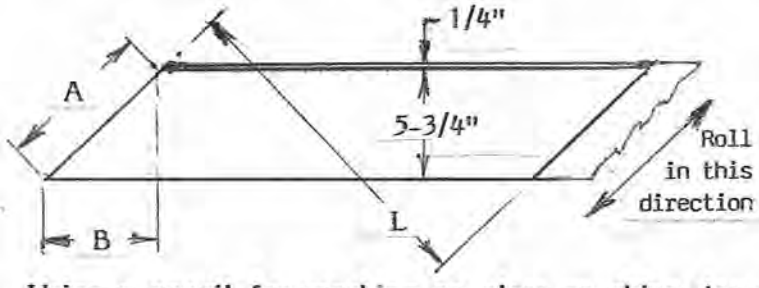






Making Spiral Lap Seam COMPRESSED AIR Tanks.

Making spiral lap seam COMPRESSED AIR tanks can be a relatively simple task. After determining sizes, diameter & length, material & tools should be at hand. If hemispherical ends are to be used, diameter of form must be quite accurate so caps will barely slip over end of cylinder. Wood forms turned on a lathe are too much work to prepare & then slipping completed cylinder off of form can be hard to do. A much simpler form can be made starting with any cylindrical object such as a mailing tube which is slightly smaller than diameter desired. Spray cans or beverage cans of equal diameter can be rolled up in stiff paper or single faced corrugated cardboard to length of cylinder desired. Then the shim material, cut in following manner, should be wound around form as indicated with 1/4" overlap.



Dia.	$A = \pi D$	$B = \sqrt{A^2 - (5-3/4)^2}$
2-1/2	7.85	5.35
2-3/4	8.64	6.44
3	9.42	7.90
3-1/4	10.21	8.25
3-1/2	11.00	9.37
3-3/4	11.78	10.28
4	12.57	11.17

Using a pencil for marking on glass or china, lay out one end of roll of shim material for diameter desired. Dimensions "A" & "B" are laid out to a line 1/4" from one edge as shown. Note "L" is length of cylinder desired.
If end caps fit loosly, carefully remove cut shim material so as to avoid dents. Add turns of newspaper until end caps fit closely. Hold shim material with strong rubber bands & recheck fit of caps. DO NOT TACK SOLDER! but starting at end with outside wrap & using ample flux, solder along outside of lap seam making certain that solder flows into joint. Shift rubber bands out of path of soldering & completely solder full length of seam.
Push form out of cylinder in direction soldering began. Newspaper may adhere to inside of cylinder but it may be removed readily.
With a good light shining through cylinder gently flex cylinder along seam to inspect for 100% solder joint along full length of seam. If seam is not tight at any point swab area with flux on inside of tube using swap on long stick if needed. Solder over this area again on outside until seam is tight full length. If required, trim ends of cylinder square. Slip one end cap in place &, with ample flux, flow solder into circular seam. Wash inside of cylinder with hot water to remove all flux. Wipe dry.
Prepare last end cap by stabbing 2 holes 5/16" from edge of rim & 120° apart. Enlarge holes so that throttle & filler valves fit tightly. Remove valve core when soldering filler valve. Soldering from inside of cap makes a neater appearing job. Wash inside of cap with hot water & dry. IMPORTANT-slip cap on so that FILLER VALVE is located at end of seam on cylinder. In order to avoid getting strong flux inside of tank, use rosin core solder for this last cap. Replace valve core & needle & test for leaks with air pressure in tank. DO NOT SOLDER ON TANK WITH AIR PRESSURE INSIDE! Close any leaks found only when valves are open. Test tank behind barrier to a higher pressure than will be used in model.
Use a clean hot soldering iron, or gun type iron.
Shim material is very sharp. Handle with care.
60% tin, 40% lead solder is satisfactory but 97% tin 3% silver is stronger & brighter if available. Another solder, 95% tin & 5% antimony, is very strong.
Wire winding & tie rod through center axially are not required & should not be used.
Leave valve open when not in use to avoid wrinkling due to temperature & barometer changes.

Wire Winding of Brass Tanks.

If you must have a wire winding on your brass tank, here is one way to do it. First you need a tank which will hold the desired test pressure without the wire! You will need to make 2 pieces to hold the tank while it is being wound. These pieces can be made from balsa about 2" thick. See the "DRIVE FIXTURE" & the "TAIL FIXTURE" in the sketch below. The fixtures have recesses turned to fit the tank ends. They are mounted so that the tank will rotate truly. To drive the tank against the tension of the wire during winding, insert a pin or nail in the driving part so that it will engage one of the valves on the tank.

The wire should be wound over the top. This means that you will need to run the lathe in reverse. Set the lead screw for the widest possible feed which the lathe is capable of, up to 1/4".

Get a generous supply of brass wire .005"to .008" diameter. Mount the wire so that it can feed off of its coil or spool freely.

Put 30 to 40 psi in the tank. Clean & polish the tank. It is difficult to do after wire is in place. Have rosin core solder & soldering iron handy. Arrange a simple form of friction drag to maintain a light tension on the wire.

Check the operation of the feed screw. Mount the tank snugly between the fixtures. Solder the end of the wire to the tank, about 3/16" from an end cap so that the solder on the end cap is not melted. Wind one turn by hand turning the lathe backwards without the lead screw being engaged. Now engage the lead screw & start the lathe at its slowest speed in reverse. Keep close watch on the wire. A helper is quite helpful to keep the wire feeding properly. If lathe has to be stopped during the winding, do not disengage the lead screw. As the winding approaches the other end you can wind the last turn or so by hand turning the lathe. Then when the winding is about 1/4" from the end cap, disengage the lead screw & wind another turn. Now solder the wire fast, being careful to keep the heat away from the end cap. Secure the wire with a drop of solder. Cut the wire & bury the cut end in another drop of solder. Wind the loose wire back on the spool.

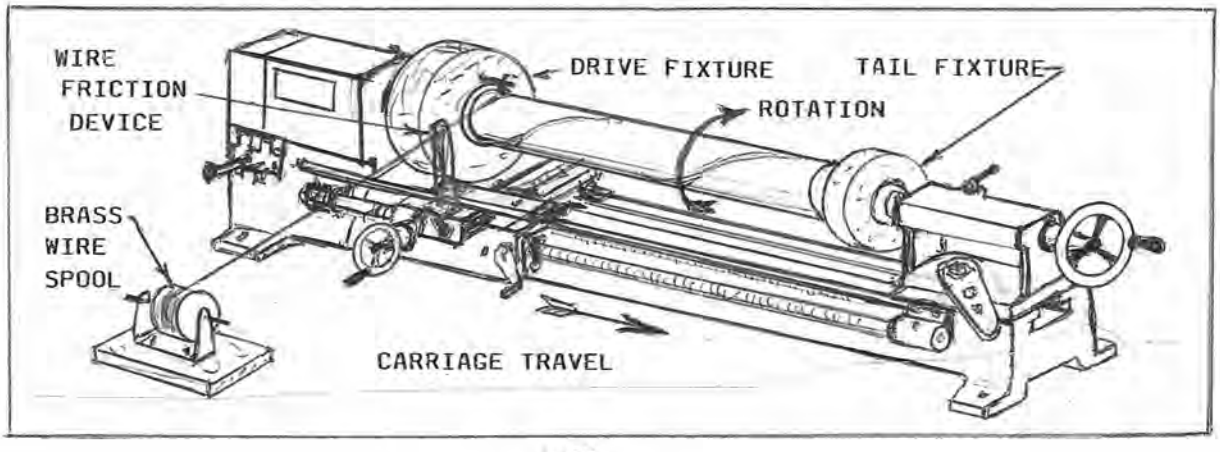
Before removing the wound tank from the lathe, coat the wired portion of the tank with several coats of clear dope or thinned varnish. This secures the wires in position so that they stay neat & clean. The coating prevents the wires from corroding. Do not touch the coating until it is completely dry. To complete the coating job, the spherical ends should receive the same coating as the cylindrical part of the tank.

My reason for using brass wire of small size is to avoid stress risers under each wire & to keep the addition of this unnecessary weight to a minimum. The elasticity of the brass matches that of the tank; local stresses under each wire would be less.

If you were simply after the appearance of wire but realize that it is of no real benefit, you could wind the tank with thread, preferably monofilament.

If you make a mess of the first try at winding the tank, you can remove the winding & start over.

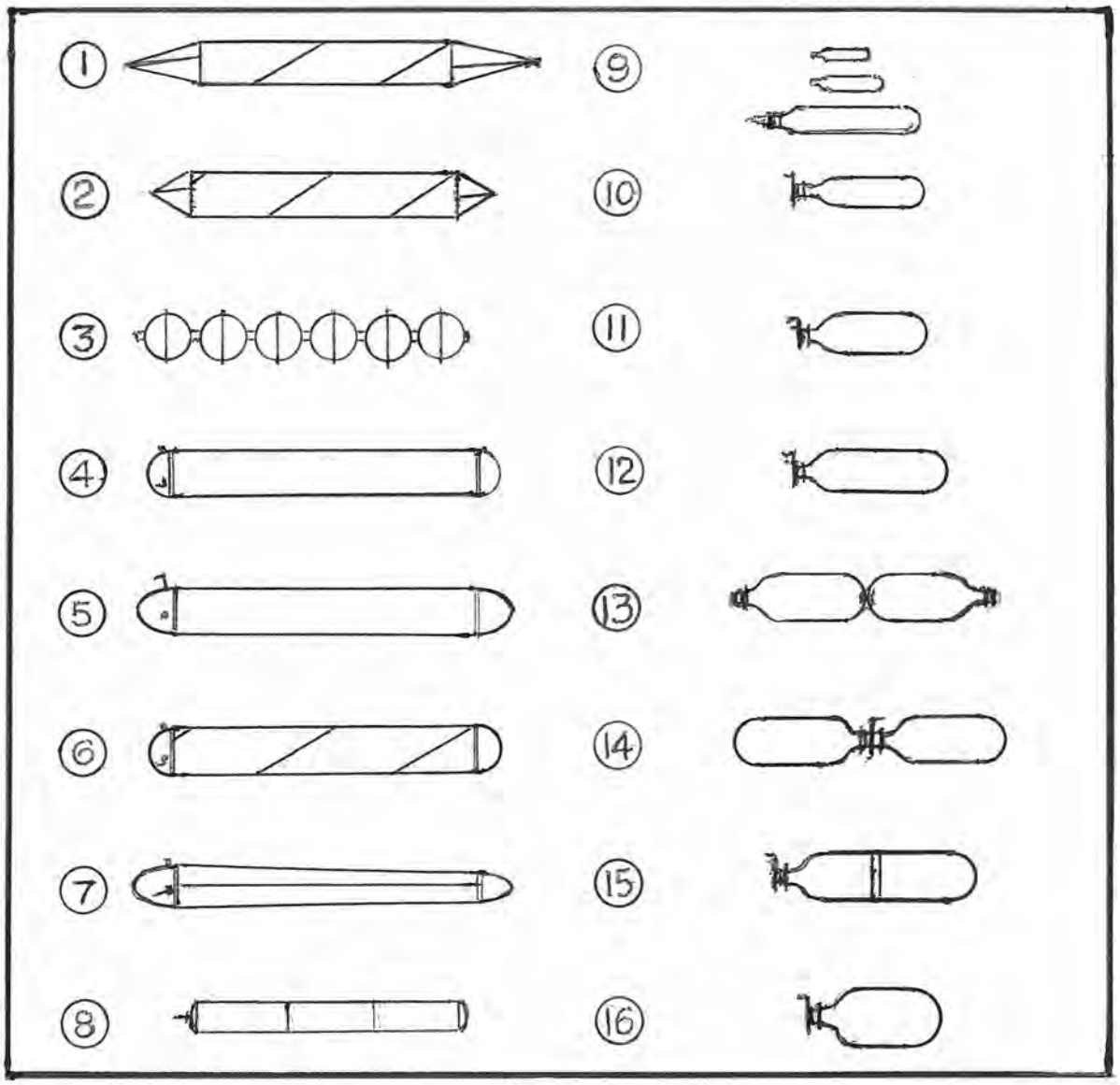
If you find too much difficulty in winding the tank, you can test the tank without the winding. You may try a plastic tank. They are lighter in weight.



COMPARISON OF COMPRESSED AIR TANKS

MATERIAL	DIA.	LENGTH	VOLUME IN^3	WEIGHT-OZ.	CU.IN./OZ.	REMARKS
Brass seamless	3"	17-1/2"	117	4.60	25.3	Seamless material no longer available. (were safe at 200 psi.)
Brass seamless	3"	26-1/2"	180	7.00	25.7	
Brass seamless	3"	29"	198	7.15	27.7	
Brass seamless	3-1/2"	23-1/2"	215	7.35	29.2	
Brass seamless	3-1/2"	26"	239	7.70	31.0	
Brass spiral	3"	24"	162	5.60	28.9	- Current popular size- .004"x 6" brass strip.
Aluminum	2.06"	17"	57	1.95	29.1	
Plastic	1-4-1/4"	12"	122	1.85	65.9	- Hemispherical ends.
Plastic	2-4-1/4"	24-1/4"	244	4.10	59.5	- Hemispherical ends.
Plastic	1-5-1/4"	12"	183	2.75	66.5	- Hemispherical ends.
Plastic	2-5-1/4"	24-1/4"	366	5.80	63.1	- Hemispherical ends.

None of above were wound with wire or other material.
Obviously plastic is lighter per unit volume than either brass or aluminum beverage can tanks. Plastic does not corrode but it is much more elastic than brass or aluminum. Consequently any support on major diameter must be resilient in order to avoid high stresses at support.



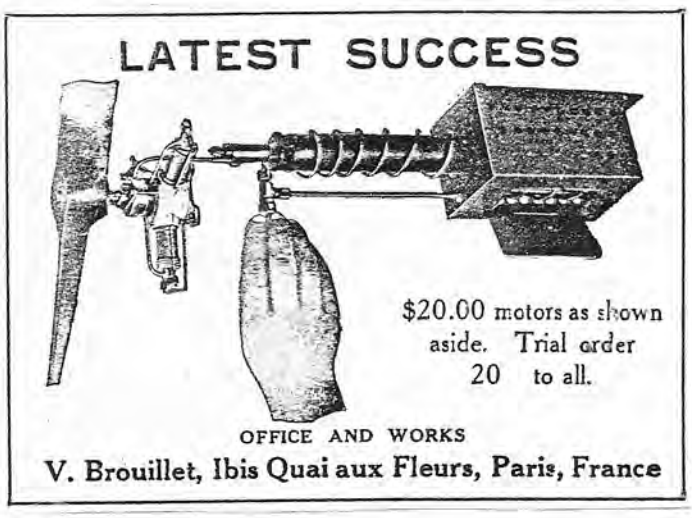
Airborn Tanks for Expansion Engine Model Aircraft.

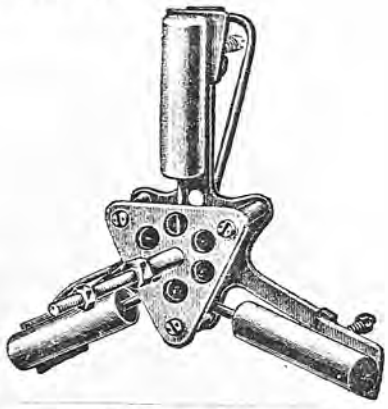
Tanks to contain the pressurized gas are one of the most important parts of a model aircraft powered by an expansion engine. Flight duration depends upon the total amount of gas which the model can carry aloft. Tank materials may be brass, steel, aluminum, stainless steel or plastics. Many types of tanks have been devised. Whatever type of tank is made be sure to test it safely at a pressure which is higher than will ever be used in flying the model. Refer to chart. The numbers match the descriptions below.

1. Tatin's tank was spiral seamed steel with conical ends. It was 4" dia. x 36" long.
2. John Stott's tank was similar to Tatin's only it was made of brass & had a greater angle on the end cones. Some early compressed air tanks sold by Gamages of London were similar.
3. Lockwood's unique tank is worth mentioning although it was one of a kind. Six 5" diameter stainless steel spheres were brazed in line. Rated at 1,000 psi. burst pressure this tank held 395 cubic inches with a weight of only 12 ounces. Unfortunately thin spheres of stainless steel & the brass toilet floats are not readily available.
4. Hoosier tanks were made with Fulton Sylphon seamless brass tubing extruded by very high pressure to .0045"average wall thickness. Diameters of 2.5", 3.0" & 3.5" were made in lengths up to 30". Hemispherical brass ends were used. When Fulton quit the manufacture of this tubing seamless tanks were no longer available. Burst pressure was 500psi. for the 3" diameter tanks.
5. Ott tanks used the Fulton thin brass tubes. The valves were heavier & ends oval.
6. The spiral wound tank of shim brass replaced the seamless tanks. .004" shim brass is actually better than the seamless extruded material. Tanks are lighter than the older seamless type. Be sure & test any such tanks before use in a model. See "Making---"
7. Numerous tapered tanks have been used. A spiral seam can not be readily used on a tapered tank. The straight seam tends to bend the tank under pressure. Earlier Ott tanks were tapered no doubt for appearance. However they weigh too much for their volume.
8. Aluminum tanks are made in a number of lengths & diameters. See data for making.
9. CO_2 gas & liquid is used in some expansion engines. Special tanks are required.
10. Plastic tanks come in 1,2,2-1/4 & 3 liter sizes. 1 liter size is used on some air retract landing gear systems but is too heavy for expansion engine use. 2 & 2-1/4 liter sizes if pressure tested make ideal tanks for compressed gasses. They are less than half the weight of comparable brass & most aluminum tanks.
11. This shows the relative size of the 2 liter tank, compared with the ----->
12. 2-1/4 liter bottle below it. In England, they use the 2-1/4 bottle as a sales device claiming that the extra 1/4 liter is "free" when you buy their brand of soda!
13. Joining plastic bottles provides more gas volume than ever before for less weight. With this type of joining, the engine can be mounted to one of the steel caps. Joining requires a bolt, preferably aluminum & drilled through. Epoxy for sealing & a nut put on tediously with long socket wrench extensions completes the assembly.
14. The joining at the necks is more rigid but requires that the motor be mounted at a separate location than on the tanks.
15. Joining plastic tanks on the major diameter as shown is not recommended. The plastic is not easily cemented. The elasticity of the plastic reduces the safe pressure to such a low figure that it is not weight to volume effective.
16. Most 3 liter containers have a larger neck & require a larger steel cap than 2 or 2-1/4 liter bottles. The larger diameter means that the 3 liter bottles must be used at a lower pressure. However the greater surface area allows for more heat to be regained from the atmosphere to make up for heat lost due to the expansion of the gas.

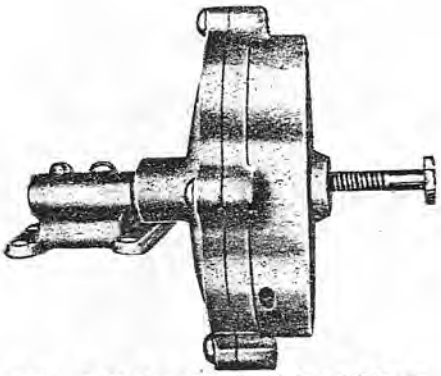
Note that the type #13 twin tank may be readily streamlined with a length of plastic bottle split lengthwise & taped so as to make the twin tanks into one continuous cylinder. A strip of "Mylar" drafting film would be a little lighter in weight.

SOME INTERESTING ENGINES OF YESTERYEAR.





Braune 3 cylinder radial engine with oscillating cylinders.



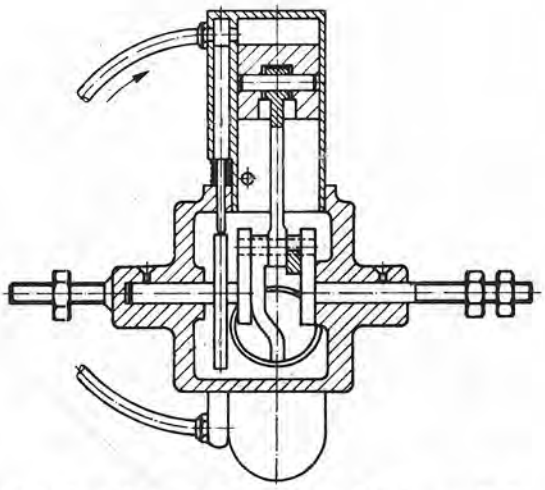
The Cellulose Turbo Model Motor

write to

The Co-Operative Aero Association, Muncie, Indiana



Saran/Bing Autoplan piston bypass valve 3 cylinder radial engine-see schematic.



Section through Braune 3 cylinder radial- 1-Feed pipe; 2-Cam operated, spring return air inlet valve; 3-Exhaust holes; 4-Shaft 5-Cam



Model Aviator Products (Joe Ott) Ott's second type open frame, a short rod motor-using 1st type parts! 1932 Popular Aviation ad.

The "Latest Success" is a steam engine made in France appealing for $$$ sales in the United States. The tanks for water & fuel were enclosed in the box on the right hand side. The box also served as a heat economizer. The hand is shown on the burner adjusting needle valve knob. This 3 cylinder radial engine has a single push rod operated valve for each cylinder.
The degree of success of the "Latest Success" is not known.

Braune 3 cylinder radial engine with oscillating cylinders appears to have been a much lighter engine than the Braune 3 cylinder radial engine shown at the left below. Both engines would work with steam as well as air. The fixed cylinder radial with its cast case & bulky pistons would be too heavy for a compressed air model. The Braune engines were of German manufacture.

The Cellulose Turbo Model Motor is by its name a turbine type of motor. Turbines are too high speed of rotation for propeller driven models. Reduction gearing would would make the unit too heavy. Turbines of this type are not efficient in the use of air. There have been one or two other turbines engines but they have never been successful in the market-place to date.

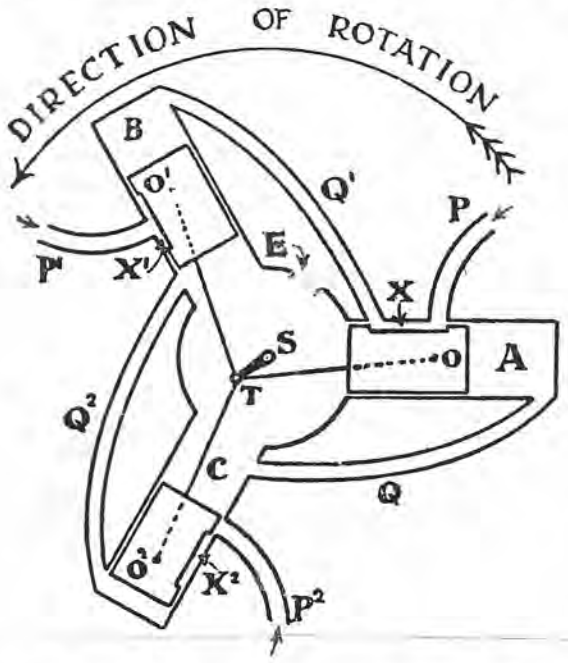
Saran 3 cylinder radial is shown below Braune oscillating cylinder engine. This engine was also known as Bing Autoplan. It was made in Germany. Many were sold in England & in United States of America. They were sold as complete model airplanes ready for minimal assembly. A stirrup pump was provided for charging. Engine was mounted on an aluminum bracket. This bracket was fastened to tank with two nuts engaging studs projecting from tank. Also fastened to this bracket was front landing gear wire. By pass in piston was of novel construction. Body of piston had 2 holes offset in angle & height. A second thin walled piston is soldered inside of main piston so that a dimpled ridge extends between holes in outer piston. See additional data on Saran/Bing accompanying the schematic.
It should be noted that in these piston valve motors there is always one intake on one side of the cylinder. When this intake port hole is covered by piston, pressure still exists in blocked intake pipe. Therefore this piston is forced against opposite side of cylinder. Clearance between piston & cylinder becomes eccentric. This eccentricity increases air leakage slightly & reduces efficiency & duration. Friction between cylinder & piston would increase slightly. In the piston valve engine there is little that can be done to change timing-air inlet & outlet cut-off angles. Slight rotation of piston can change alignment & area of air inlet openings.

The Braune 3 cylinder radial engine with fixed cylinders is shown in the sectional view at the bottom left side. This engine would be a bit heavy for COMPRESSED AIR due to heavy pistons & crankcase. It would be suitable for steam power in model boats. It is shown because of its pressure return piston type of cam operated valving. Note the exhaust holes in the cylinder walls & the oiling holes in the housing for lubricating the shaft.

Joe Ott's "Look-Fellows-Look" featherweight motor was advertised in 1932. Earlier Ott motors were made with various numbers of cylinders & had long thin but wide perforated connecting rods with cylinders mounted at ends of radial frame arms. To salvage a stock of existing parts from this first series of engines, engine illustrated was designed. About the only new parts were connecting rods now much shorter & not subject to buckling failures. Loose fits & short & wide leakage paths for air to escape before doing any work made this engine short lived too. With better fitting of parts this engine would have been a reasonably good performer. See more on Ott's various COMPRESSED AIR motors & models.

SARAN COMPRESSED AIR MOTOR. Also called the Bing Autoplan.

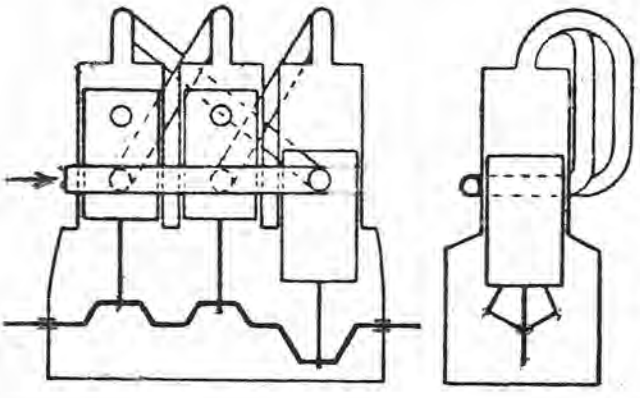
Complete Bing Autoplan models were sold in toy stores world wide. Modelers were quick to remove tank and motor assemblies and use in models of original design. Books & magazines of period showed various models powered with Bing or Saran power units. Modelers were bored with rubber models & C.A. was a new challenge. Though gas engines were available for models, they were much too heavy & expensive for most people. An extract from a description in German in a Flugsport magazine best describes this functionally unique engine. Schematic at left shows how parts interrelate. "Air from central tube is fed to cylinders through tubes P. Through channels arranged on each piston, in & out guidance of air is regulated. In diagram, cylinder B is placed under pressure from inlet P, piston channel **X**, & cross tube Q'. Cylinder C, also under pressure brings piston C beyond dead center position whereupon motor comes in motion. At the same time, cylinder A pushes dead air into crankcase where it exhausts through opening E."



A cock type air valve at front of air reservoir connects to a manifold feeding air to cylinder pipes P, P', P". Weight of tank, motor & propeller unit complete, ready to fly, is 350 grams (12-1/3 oz.) plus of course considerable weight of air when full pressure is in tank.

Tank is 3" diameter x 27" long & weighs 200 grams. Volume is 3 liters. About 250 strokes of a common foot stirrup pump (furnished in package with outfit!) provided flying pressure. Tank is wrapped with wire to "reinforce" tank. Air inlet fitting is at rear hemisphere of tank. A wire lanyard was added to later models to operate starting cock from rear of tank. A bracket bolted to front hemisphere supports motor. Propeller is two bladed aluminum alloy with blades riveted to sheet aluminum hub folded over & fastened to a nut. Propeller is 14" dia. & of low pitch.

Wing, landing gear & tail 'feathers' are attached to tank by use of tubes & clips soldered to tank. Tubes are reinforced with doubler washers soldered to shell of tank. Wires attached to stiff wire pylon & landing gear brace wing halves.



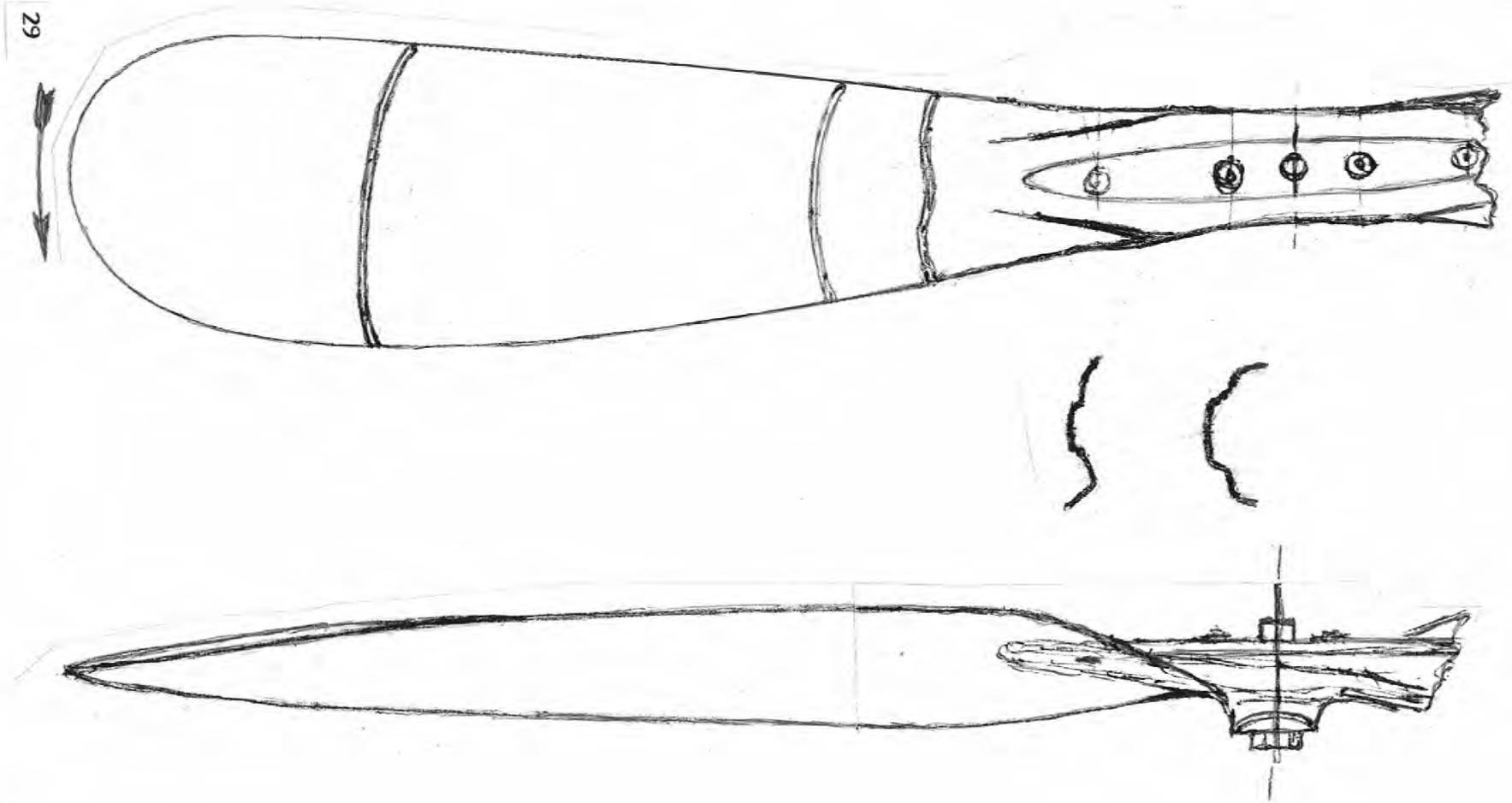
Pause of Germany manufactured several C.A. powered models which had unique engines. Schematic at left is diagram of 3 cylinder in-line motor with piston valving. Reservoir-fed manifold directs air through cylinders by cross tubes in pistons. Right hand cylinder is feeding left cylinder in diagram. Pause made a conventional 3 cylinder radial engine with crankshaft rotary valve & spun brass crankcase. Both Pause motors were efficient & powerful but heavy. Pause 3 cylinder radial is identical in appearance to Dobe-Ott 3 cylinder radial engine.

BING AUTOPLAN PROPELLER.

The plan view is a tracing around the periphery of an actual Bing propeller blade. The side view is an accurate sketch. The diameter is 15" & the pitch is approximately 7". This pitch seems a bit low. However the Bing ship flew quite well with these hard aluminum alloy propellers. Plain aluminum was almost a laboratory curiosity in the United States of America at the time that Bing Autoplan model planes were manufactured. Here was a German toy which had an aircraft quality hard aluminum alloy propeller! The center of the propeller was reinforced with a formed aluminum doubler fastened with 4 brass rivets. This formed piece nests closely within an embossed recess in the blade central area.

The wooden propeller used on the Pause COMPRESSED AIR model has a diameter approximately the same as the Bing propeller but the pitch is considerably greater. The pitch of the Pause propeller is nearly double the pitch of the Bing propeller.

The camber of the blade at the outer section shown is 1/8" & this camber is almost constant except near the tip & near the hub. The forming of the metal near the hub to provide the higher angle is interesting.



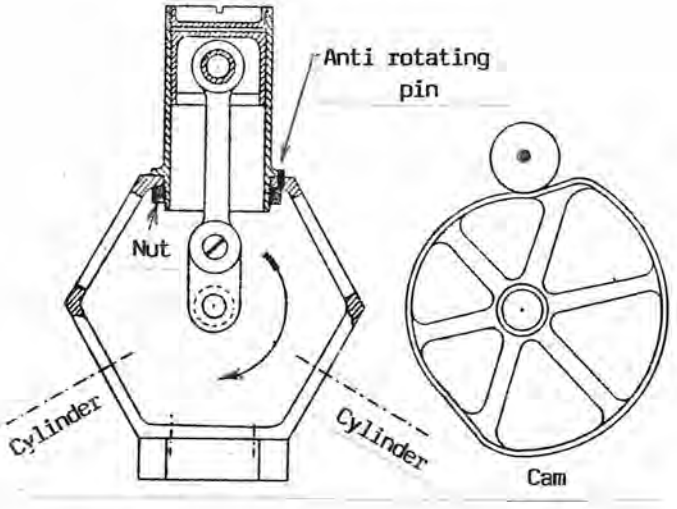
An Early English COMPRESSED AIR Expansion Engine.

This 3 cylinder radial engine was designed & tested in 1909 by Mr. Scobble for model aircraft use. The bore is 1" & stroke is 1-1/4". The steel cylinders have 1/16" walls. The cylinders are retained in the hexagonal aluminum crankcase by nuts engaging threads on the cylinder base. Anti rotating pins fix the angular position of the valve so that the actuating rollers are aligned with the cam. The piston type valves work in small cylinders with 1/32" wall. These cylinders are secured to the front of the large cylinders by brazing. The valves have a stroke of 9/32". The valve piston & guide rod confine the pressure air & admit it to the cylinder quickly just after top dead center. At bottom dead center the valve is raised so that the 'spent' air exits below the valve piston. The top of the extended valve rod is squared & guided by a square stationary part in order to maintain roller-cam alignment. (There must be a better way!) Air pressure forces the valve assembly against the cam so no spring is required. The roller is steel with a bronze bushing & a steel shaft. Brass pistons are lapped & fitted to lapped cylinders. The connecting rods are "slipper" type with about 1/5th of the inside circumference in contact with the crank pin. Cup washers trap the projections of the slipper so that the rods stay in contact with the crank pin. The steel crankshaft is 7/16" in diameter & drilled through for lightness with 1/4" diameter drill. The cam is made from solid steel. This would appear to be quite a project! The cam is pinned to the shaft after setting the timing accurately. The crankshaft is supported in a bronze bearing. Axial motion is limited to only a few thousandths by a collar pinned to the shaft. Air pipes are of aluminum copper plated & soldered to the air supply at one end & the valve cylinder at the other end.

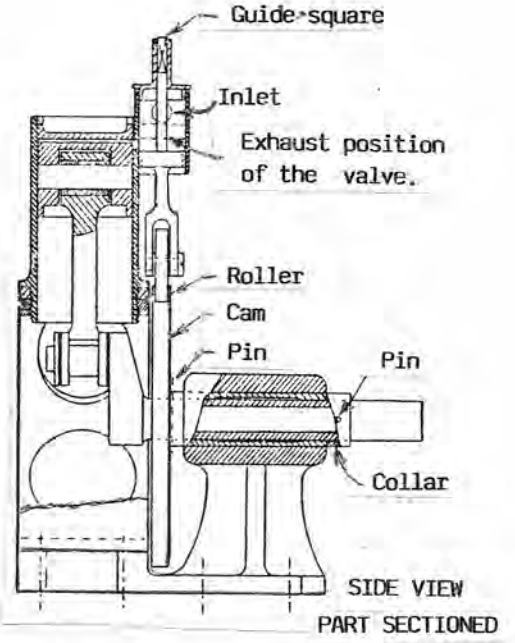
A dynamometer test gave this engine a .6 brake-horse-power rating. The pressure was about 100 psi. & the rpm. was approximately 1,000.

Weight of the engine is 32 ounces.

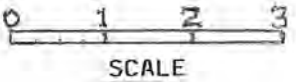
This engine is obviously not a modern expansion engine but it does contain some novel ideas for the experimenter.



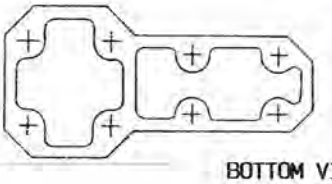
REAR VIEW
PART SECTIONED



SIDE VIEW
PART SECTIONED

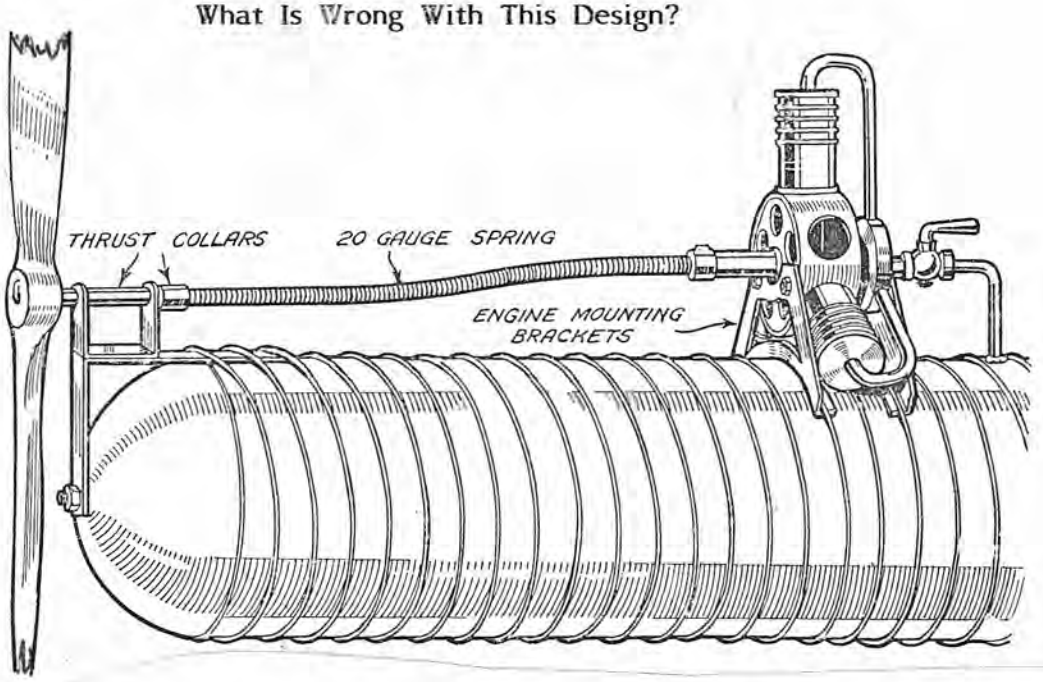


SCALE



BOTTOM VIEW BASE

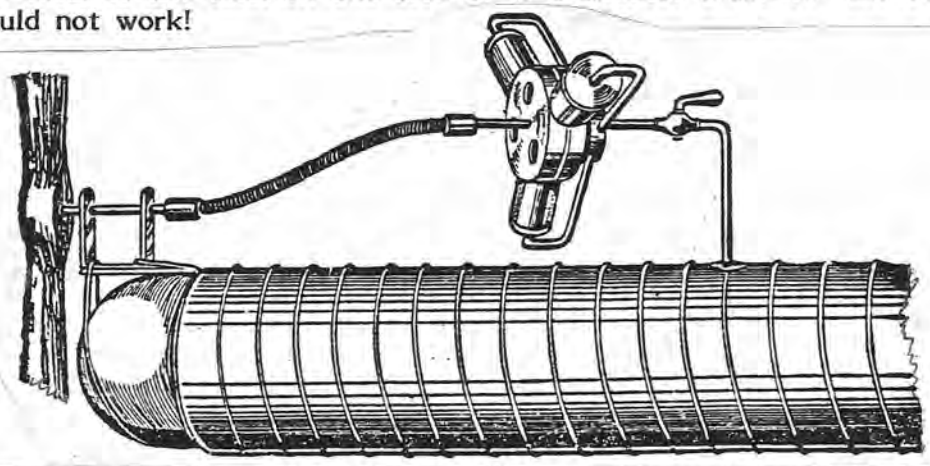
What Is Wrong With This Design?



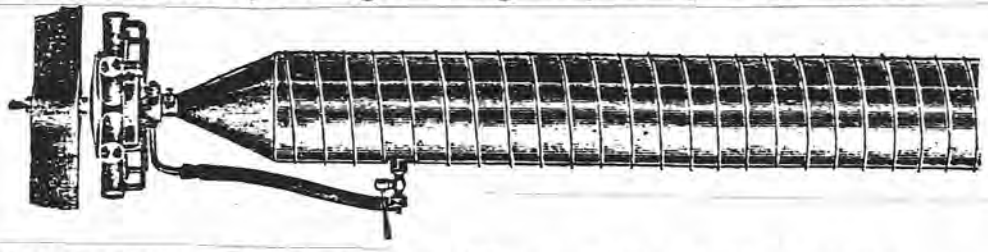
This COMPRESSED AIR power plant arrangement appeared in a model airplane book some time ago. I have listed a number of "no-nos" of varying degrees of importance. Can you name some more?

1. The flexible drive shaft adds friction, weight & complication. In addition it can whip or move around as it revolves, an undesirable condition.
2. The thrust bearing & bracket add friction & weight.
3. Using the wire around the shell to hold the motor brackets to the thin tank is very impractical & presents an almost impossible task to accomplish. It is a most insecure mount for the engine unless the brackets were soldered to the thin tank shell. This would be unsatisfactory too due to stress risers at the points of contact.
4. Steel wire winding has an elastic modulus of about 30,000,000 while the brass tank shell has a modulus of about 12,000,000. Consequently the brass grows under pressure much more than the wire. The steel wires at the lines of contact with the brass create stress risers. In addition the steel rusts in time & can snap under pressure. The wire adds weight which we do not need.
5. There is no driving flange to provide driving torque to the propeller.
6. There is no nut to retain the propeller to the shaft.
7. The single rivet which fastens the "U" shaped piece holding the propeller shaft can pivot & allow the propeller to point left or right.
8. The angle piece holding the "U" shaped piece is too insecure to remain in a fixed position & handle all of the forces which would be applied to it.
9. Any bump on the propeller would shove the angle bracket to the rear & probably damage the tank shell.
10. Fins on a COMPRESSED AIR engine add weight & are not required for strength or for cooling.
11. Mounting the air connection from the motor through a hole in the side of the tank creates an unbalanced stress condition with a local stress riser. Operating the throttle valve especially of the cock type shown requires considerable effort. The joint with the thin shell material would not withstand such force for very many times without failure later, or more likely sooner.
12. The air distribution valve on the engine is of large diameter & requires considerable torque to operate reducing the overall efficiency of the engine.
13. The full surround crankcase, even with holes, is still too heavy for a COMPRESSED AIR engine.
14. Cock type throttle valve looks like it would require a pipe wrench to install it.
15. Conclusion: such inept designs have not benefitted model aviation.

Another almost identical mounting arrangement adds a couple of additional "no-nos"! Anchoring the propeller bracket with wire in 2 places is a very impractical method having little or no strength where much security is desired. Then notice the way in which the motor is left dangling up in the air with an ell shaped tube fastened to the thin shell of the tank on one side & to a flexible shaft on the other side. It just would not work!



Below is another engine mount which would probably work but has some undesirable features. It appears to be a rotary engine which is supported by a long cantilever overhang from the cone end of the air tank. As a tractor application this mount would be most vulnerable to damage. The flexible plastic air tube is in itself a reasonable method. However the connection of the air tube to the valve which is mounted on the thin shell of the air tank is an unsatisfactory location. Stress concentrations around the valve mounting plus the flexing due to the operation of the valve are certain to produce failure sooner or later. Then the wire tank winding has been discussed before.
This is an outfit sold by Gamages in England probably in the 1920s.



COMPRESSED AIR Engines as Advertized for Model Aircraft

Name	Description	Country	Date
Beach	3 cylinder rotary & 2 cylinder radial		
Bing	3 cylinder radial	Germany	1914
Bohaboy	2 cylinder radial & 6 cylinder rotary	USA	1928
Braun	3 cylinder radial	Germany	
Gamage	2,3,4,5 & 7 rotary	England	1919
Collins	3 cylinder radial	USA	
Dobe-Ott	3 cylinder radial	USA	1930
Hetherington	3 cylinder radial	USA	
Miniature	3, 6 & 8 cylinder radial	USA	
Nomie	3, 6 & 8 cylinder rotary	USA	1908
Gyroette	6 cylinder rotary	USA	
Ott	1,2,3,4,5 & 6 cylinder radial	USA	1929
Pachasa	2 cylinder radial	USA	1928
Pavely	3 cylinder radial	England	
Pause	3 cylinder radial & 3 cylinder in line	Germany	
U.S.Model	2 & 4 cylinder radial	USA	1929
Wading River	2 cylinder radial	USA	
Whirlwind	3 cylinder radial	USA	1929
Jonathan "Z"	1 cylinder radial	Italy	1989

Other engines may have been produced in quantities greater than one.

Simple COMPRESSED AIR Motors

Any person who can drill, file & solder should be able to make a good twin cylinder opposed COMPRESSED AIR engine. Many opposed twins have been built in a variety of sizes & with a variety of refinements intended to improve performance. By using care in fitting pistons & valve shaft closely, & by timing air delivery to cylinders accurately, you can make a very efficient running COMPRESSED AIR motor. A first example of this type of motor is perhaps a little small & tedious to build. It has been included for those who like small projects & because it was made by the late & famous Jimmy Walker.

What features make a good engine? 1. Light weight. 2. Smooth running surfaces of cylinders & pistons which fit very closely, enough to make a popping sound when piston & rod assembly is pulled from cylinder. 3. Piston reasonably long to minimize air leakage. 4. Shaft surface & valve bore very smooth & close fitting to keep air losses to smallest practical amount. 5. Length of leakage paths for high pressure air to atmosphere generous. 6. Arrange pressure air so that propeller thrust assists in making a rotary air seal. 7. Keep air pipe diameters & lengths to cylinders small because air volume of pipes is a loss. 8. Small air reservoir at shaft valve intake makes feed pipe connection simpler & improves air feed to cylinders. 9. Valve timing must allow air to enter cylinder immediately after dead center, & cut off well before end of stroke for best efficiency. 10. Engines must be reasonably durable without sacrificing much weight, to retain lightness. 11. Provide a high compression ratio.

1. Light weight is vital in a COMPRESSED AIR model due to limited air capacity. This is comparable to rubber models with limited turns of rubber. Lightness is not to be sacrificed for loss of other important factors. Brass tubing with .015" wall or barrels of ni-cad batteries are light & make smooth bore cylinders.

2. For smooth outside diameter of pistons & inside diameter of cylinders, lapping is most common & practical method. Smooth surfaces plus frequent oiling with an oil which will be effective for at least one complete flight, or tank full of air, provide a most efficient engine.

3. Pistons should be almost as long as their diameter or even longer. Short pistons wear more rapidly & short length of air leakage path leak more air than longer pistons.

4. Shaft valve & valve sleeve should be very smooth & lapped to a very close fit, similar to fit of piston & cylinder. Slight leakage of air acts as an air bearing but only a slight leakage can be tolerated.

5. Making leakage paths of high pressure air as long as conveniently possible provides for less air leakage & for best use of air as a bearing lubricant. Leakage paths for exhaust air may be short because that air has no more energy which can be captured.

6. For a tractor engine, exhaust is better in front with high pressure toward rear. In this way, thrust of propeller pulls on shaft & rear thrust bearing acts as a rotary seal similar to water pump seals in automobiles & gas seals in refrigerators. This helps to save air. Similarly a pusher engine should have high pressure next to propeller in order to use thrust as an aid to sealing high pressure air.

7. Air volume of pipe from valve to cylinder is a loss with each stroke. This amounts to a considerable loss of air & duration if pipes are long & of large inside diameter. Valving air at cylinder head avoids this air loss. However only an inverted cylinder with a walking beam to operate crank can provide a zero tube length from cylinder to valve without mechanical complications & friction losses. See walking beam engine.

8. A small air reservoir close to cylinder(s) provides a more even flow of air from tank with less pressure loss in pipe. Generally, a small reservoir requires a single pipe for connecting tank & engine. Several engines shown in this book have awkward "Y" or loop connections which a small reservoir would have eliminated.

9. Unlike gasoline engines which "fire" before top dead center to allow time for flame propagation to produce pressure, air pressure is at valve & must not be admitted to cylinder until up to 5° past top dead center. If pressure air is admitted even a very few degrees before top dead center, a reverse pulse will be felt by piston & reduce power delivered, or even prevent engine from running. Valve timing to cut off air well before end of stroke allows some angular motion of crank during which air can expand & deliver more of its energy usefully. If we could introduce full available pressure in cylinders more quickly with respect to angular position of crank, we could cut off

air sooner & thus allow even more expansion time. We can actually do this by making ports square or rectangular rather than round & by making chordal width of ports less than diameter of holes. Power output or efficiency or both may be improved by use of narrow rectangular ports.
10. Durability is important. Careful design & selection of materials will accomplish much toward attaining durability. However nothing keeps parts from wearing any better than applying a few drops of oil before each flight. Always oil engine but never put oil into tank. Under pressure, oxygen in air is concentrated & one early report of a tank test indicates that a minor explosion with a flash of light may have occurred when test tank burst. Running a COMPRESSED AIR engine just for sheer "joy" of seeing it run does not contribute to durability.
11. That ratio of maximum cylinder volume at bottom of stroke to minimum cylinder volume at top of stroke is called "compression ratio" in our COMPRESSED AIR engines. Highest possible ratio is best. Any air volume at top of stroke is wasted air volume & results in less duration from a limited supply of air. One way which will provide a high compression ratio is to assemble engine with a thin washer or a paper disc on top of piston & with crank at top dead center, slide cylinder to touch this spacer & solder cylinder in position. Then remove spacer. If you want to use cup washers to seal pistons, make cups shallow & use a keeper as thick as the cup to keep waste air volume small.
From these observations a two cylinder motor is about as easy & simple to make as possible & powerful enough to fly models of considerable wing span depending, of course, upon bore, stroke, pressure & workmanship. COMPRESSED AIR models of 5 & 6 foot wingspread have been flown with a twin cylinder engine. So let us make one of these powerful yet simple little twins.
Refer to drawing.

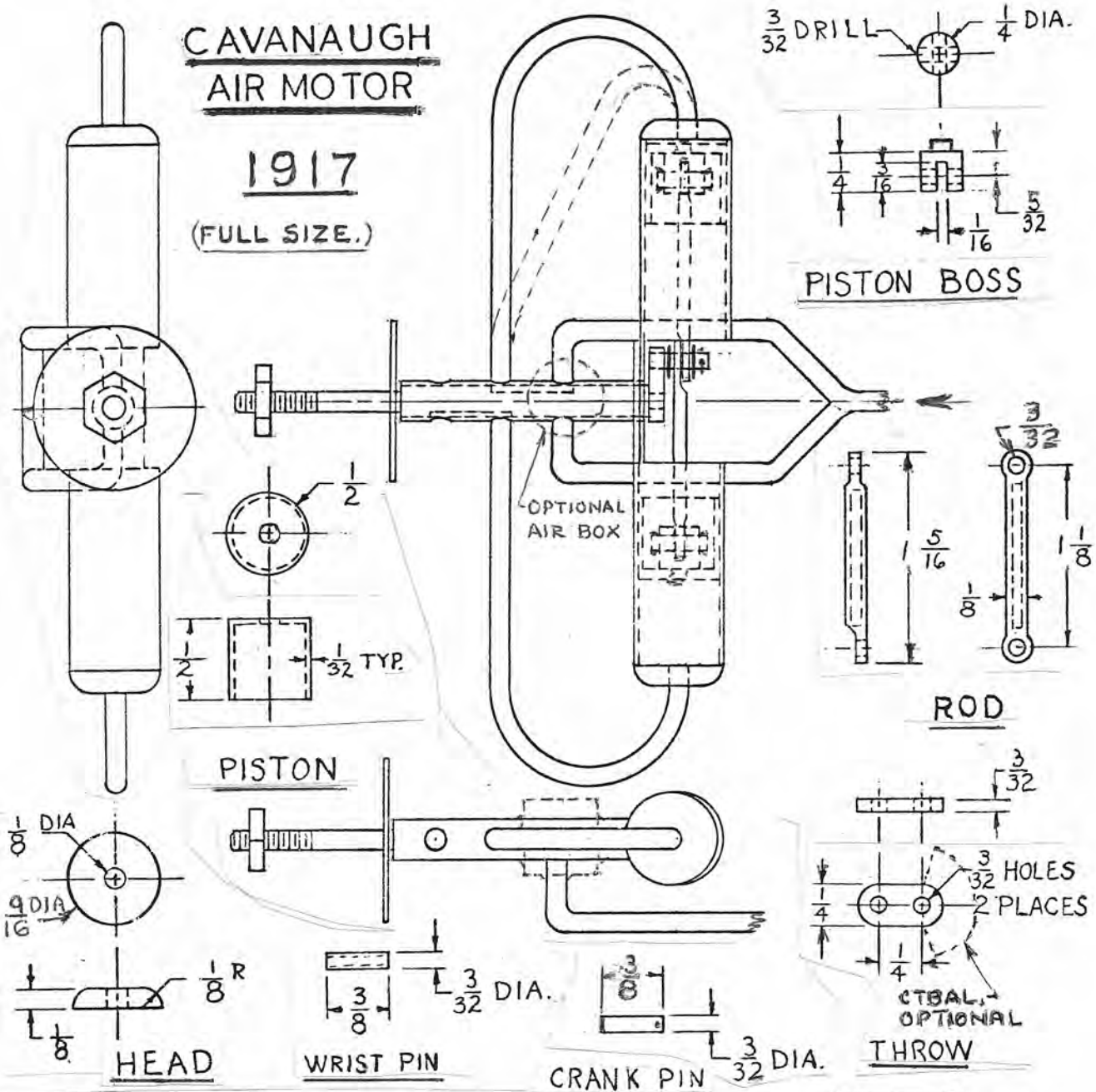
Cavanagh COMPRESSED AIR Engine.

This 1917 model expansion engine was designed primarily for use with COMPRESSED AIR. It is one of the more simple engines to construct. Most of the parts can be made from odds & ends found around the shop. With its 1/2" bore & stroke, it will be a very powerful engine if the parts are closely fitted by lapping & the timing is close to the best angles.
The crankshaft is made of steel preferably drill rod if available. The bearing/valve sleeve is made of brass & very closely lap fitted with the shaft. Brass tubing which is flattened on the ends as shown in the drawing is used to make the simple connecting rods. The wrist pins are brass tube. They can be quickly assembled to the piston boss & connecting rod by simply snipping off the tube with a diagonal cutting pliers. Piston to cylinder head clearance dimensions indicate a 1/16" clearance. Since the air volume of this space is lost or wasted air at each revolution, you may wish to shoulder the cylinder head enough so that the piston will barely miss it. This will save considerable air.
The thin cylinders may be a bit difficult to cut without deforming the thin material. The finest toothed jeweller's hack saw blades may do the trick. Use of a snug fitting dowel rod inside of the cylinder will help to prevent deforming of the metal. Be sure to remove all fins & burrs from the parts
As drawn, the shaft has a 1/32" end play with the sleeve bearing. It would be better to reduce this to .001" or .002"-the least possible without play to avoid binding. This closer end play reduces air seepage.
The extra large bend radius in the long air pipes from the valve to the cylinders wastes quite a volume of air at each revolution of the engine. Make this bend radius as small as possible as shown by dotted lines. This would not only reduce wasted air volume but it would save weight & brace the cylinders better.
The twin feed pipes branching from the tank air supply pipe would be better if it was eliminated. A single pipe can be used if a 1/2" length of 1/2" diameter thin wall tube of brass is X drilled with a 1/4" drill. This little air box should be slipped over the bearing to straddle the intake holes & soldered in place. It should be capped on one end with a disc of thin brass & on the other end with a washer. The washer should have a 1/8" hole into which is soldered the air supply pipe from the tank.
You may see many other revisions which you can make. By all means do so since that is the fun of making these engines-trying to make them work even better than the originals.

CAVANAUGH AIR MOTOR

1917

(FULL SIZE.)



PISTON

PISTON BOSS

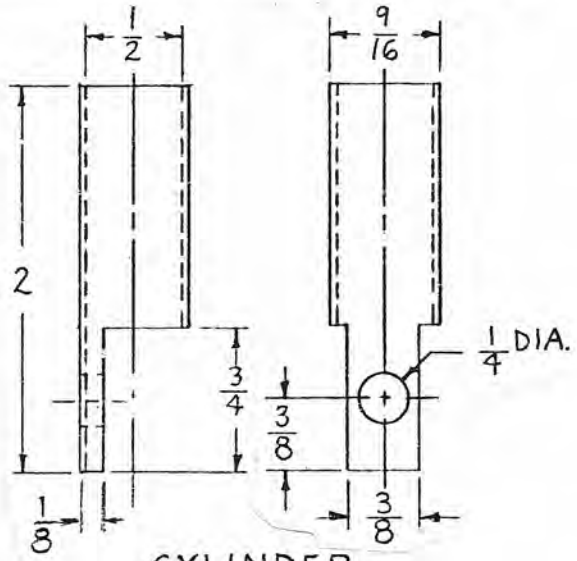
ROD

HEAD

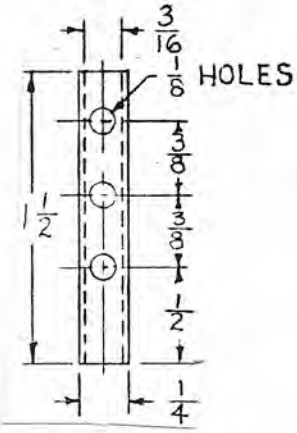
WRIST PIN

CRANK PIN

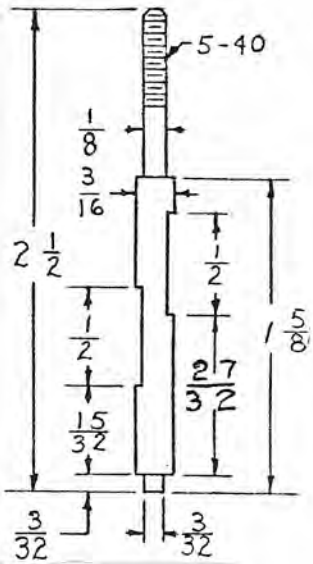
THROW



CYLINDER



BEARING



CRANK

The Pachasa COMPRESSED AIR Engine

William Pachasa built this rather simple twin cylinder COMPRESSED AIR Engine. His brother, Edward prepared a drawing with all of the details except the air pipes & a tank. These drawings along with a brief description were published in the March, April & May 1928 issues of "The Model Maker".

The well known Cleveland Model & Supply Company was operated by these men. Some time later they changed their name to Packard.

Apparently 1/64" wall tubing such as is currently made by K.& S. & others was not available to William in 1928. The use of 1/64" wall brass tubing in place of the 1/32" wall tubing used originally would reduce the weight of this motor. The valve & bearing sleeve should remain the 1/32" thickness in order that the air tubes can be soldered more securely.

The pistons (E) were originally made from hard fiber rod. The very short 1/4" length of contact of the pistons with the cylinder (B) walls is not adequate for long wear & for restricting air leakage. Unless you must have a true copy of William's engine, a longer contact is recommended. See pistons used on other expansion engines. The length of the piston skirts should be about the same as the stroke. What ever length & material, the piston should fit the cylinder as closely as you can make them fit without very much friction. The friction will lessen during the running in period.

William did not want the shaft to have axial play when there was no propeller installed. To avoid this problem, which could otherwise bend the rods, he soldered bushing (G) to the shaft (I) so that there would be less than .001" end play. The propeller thrust made an airtight rotary seal on one end & a very minimum of air leakage at the other end.

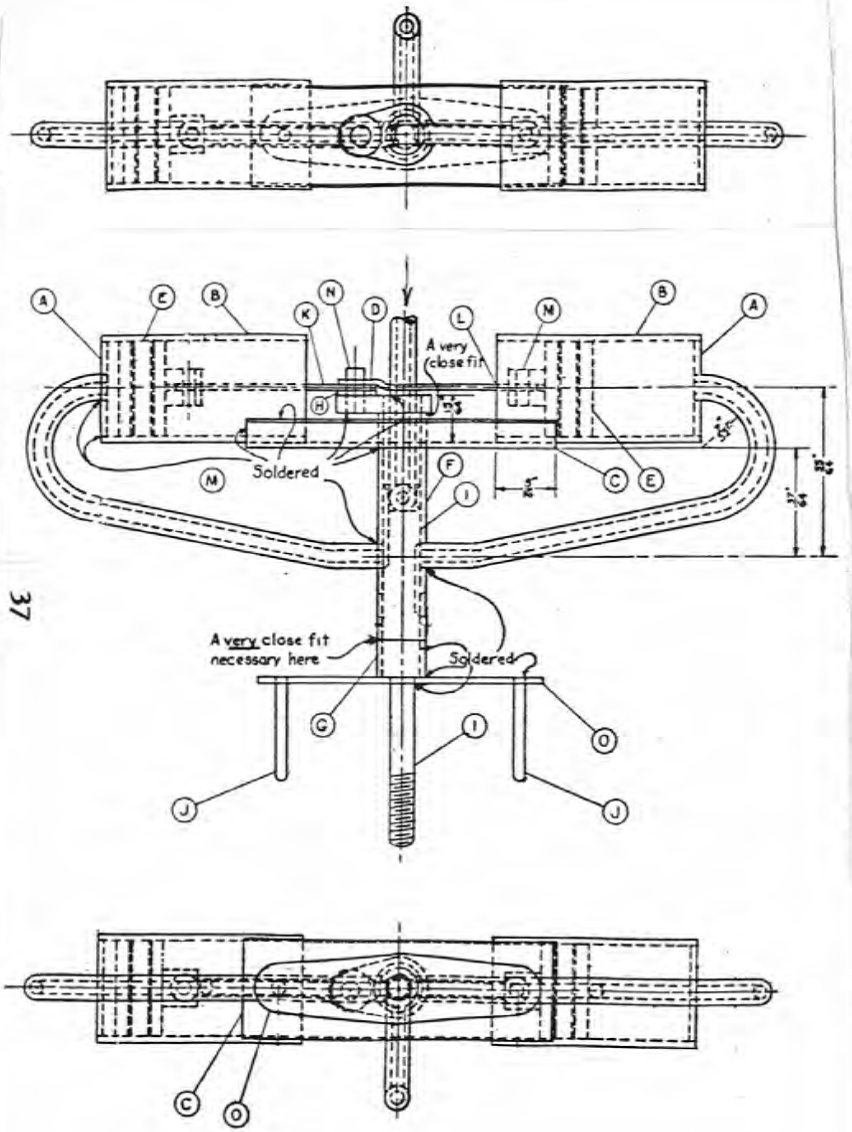
The drawings show an offset in one connecting rod (L) & one connecting rod (K) is straight. Making both of the rods straight is much easier. The 1° angle of the connecting rods with the centerline of the cylinders will not affect the operation of the engine in any way & will actually improve the appearance of the engine.

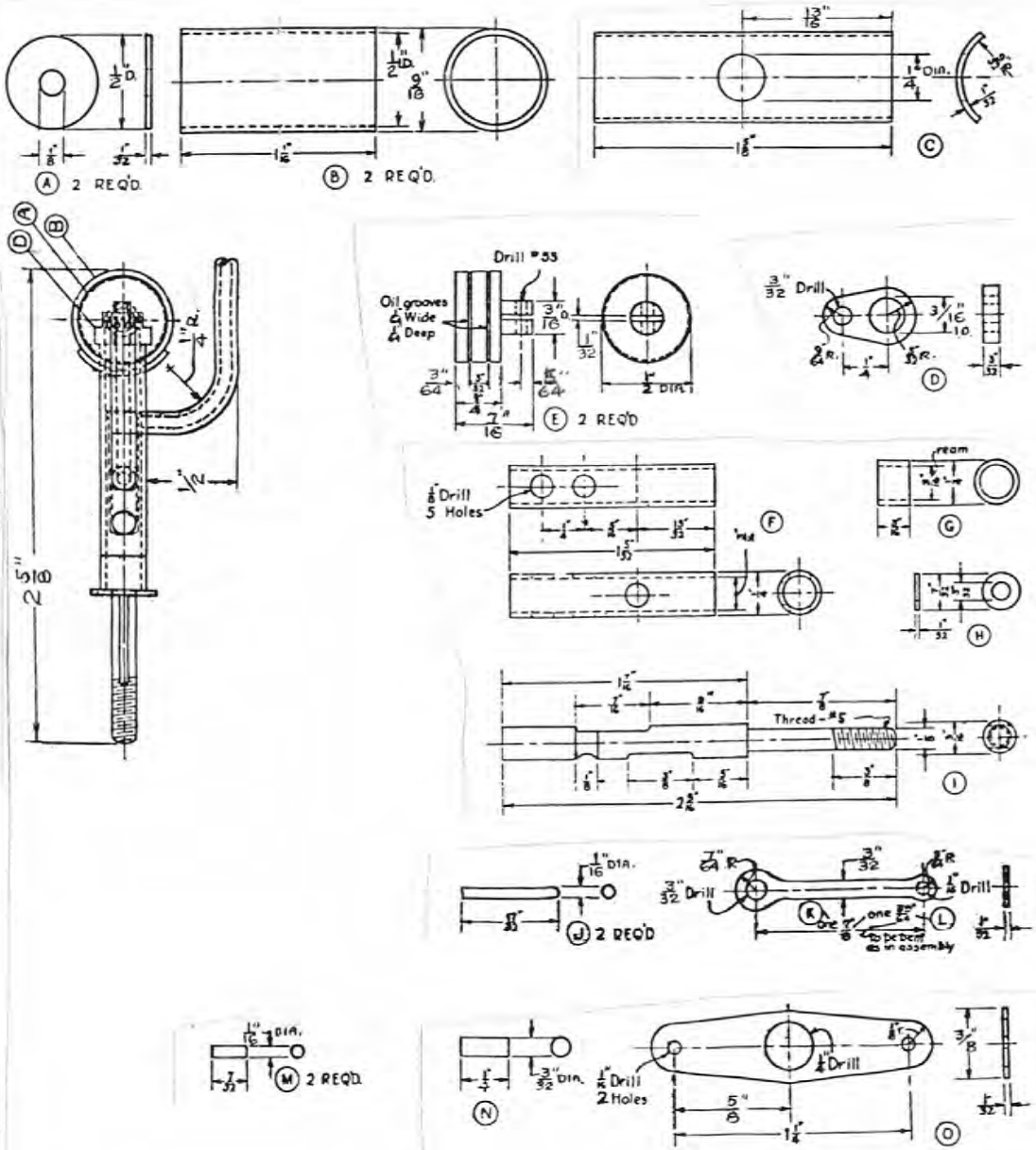
The drawings do not show any means for retaining the connecting rods on the pin (N). In operation they would wear slightly & slip off of the pin. The most simple method of retaining the rods in their proper place would be to drill a small hole crosswise near the end of the pin. Use a second washer (H) on the outside. Then a wire or tiny cotter pin through the hole completes the job.

Assemble the cylinders (B) to the frame (C) so that the cylinder heads & the top of the pistons clear each other by no more than the thickness of a heavy piece of paper. This will provide the best possible air use efficiency.

Edward mentioned in his write up that the important timing function was not shown accurately. The builder of this engine is left the chore of properly locating the crank with respect to the flats. This can be done closely by eye but by blowing air through the engine as the shaft is rotated by hand can be helpful. When the proper position of the crank (D) is found, it should be tacked with solder first & then cross drilled & pinned.

As in all expansion engines, the close fitting of the moving parts & the proper valve timing are the more important keys for making an efficient good running engine.





2-CYLINDER COMPRESSED AIR ENGINE

BY MR. EDWARD T. PACHASA

Landis Two & Three Cylinder Radial Expansion Engines

These engines were described in Model Airplane News over 50 years ago! Also the Engine Collectors' Journal of July/August 1970 Issue No. 36 had an exact copy of the original M.A.N. two cylinder Landis article & drawings. With the cylinder size shown, these engines should be very powerful if well made & closely fitted. The engine plans are just as they appeared years ago-as Landis drew them. Note that some of the parts are interchangeable between both engines. So why not make enough of those parts to be able to assemble both a twin & a three cylinder model?

Should you have difficulty in locating suitable fishing rod ferrules for the cylinders & pistons, thin wall -.015"-telescopic tubing is obtainable at most hobby shops. The outer surface of the part to be used for the pistons should be uniformly coated with solder-tinned-in order to make a closer fit which can be lapped with the cylinders. An alternate would be to use old 'dead' Ni-Cad. batteries for making the cylinders. WARNING-the cadmium inside of the batteries is VERY POISONOUS. Therefore be unusually careful to dispose of the material removed from the insides of the cells in a safe manner such as burying. Also wash all tools & especially your hand if you do not wear gloves while preparing the cylinders. I make my Ni-Cad cylinders by chucking the end which I will NOT use leaving more than the length needed for the cylinder projecting from the chuck. If the battery is rotating true-not wabbling-I scribe a fine line at the length of cylinder needed. The thin shell of the battery case is very light for our purpose but it can be dented very easily by the chuck jaws if very much pressure is applied by any tools. Consequently I use a small grinding wheel to part off the cylinders, with the lathe running slowly. If done slowly the good cylinder part can be pulled off of the tightly packed electrolyte material. Sometimes I have to dig & drill & twist it out. When I get the required number of cylinders, I either make pistons from hard aluminum alloy rod or, if I am real lucky, I find batteries which fit as closely as good fishing rod ferrules.

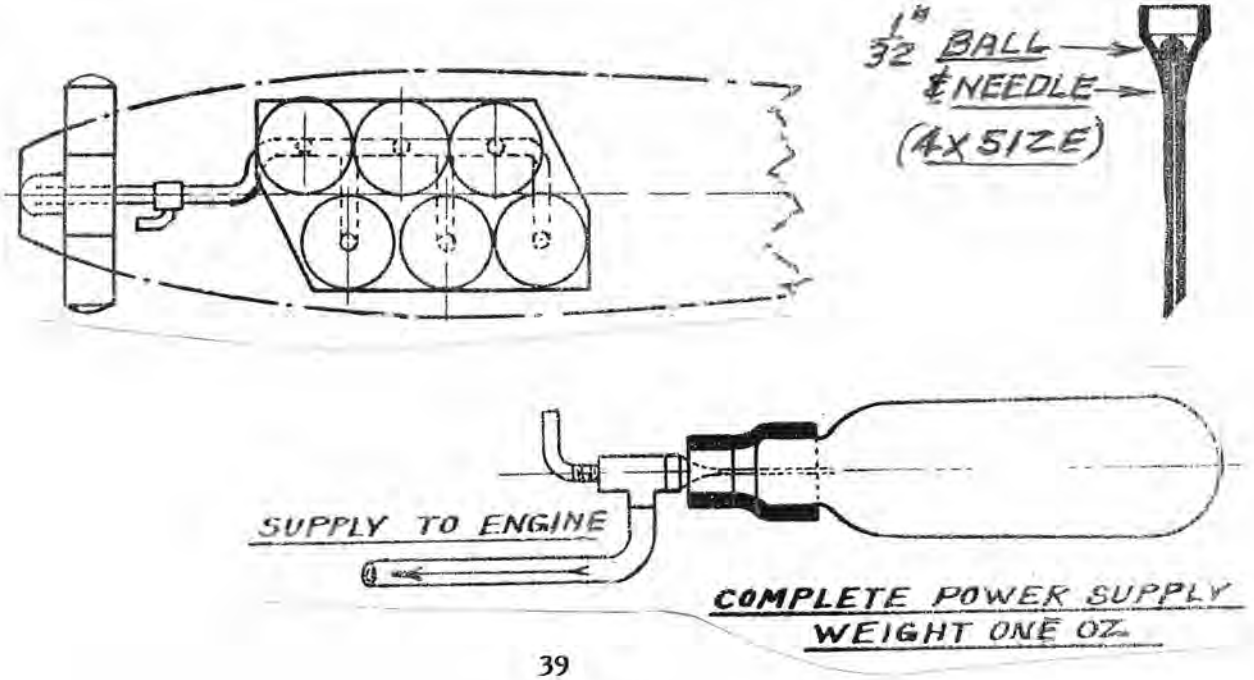
Whatever material of the pistons, they must be lapped very carefully with the finest of scouring powder such as Bon Ami. NEVER use emery as even the finest is too harsh & would spoil the surfaces to be fitted. Spend plenty of time in order to obtain an extremely close fit that slides easily yet makes a "pop" sound when pulled from the cylinder. The same care should be used in fitting the shafts & valves to their sleeves to get very close fits that still run without appreciable drag.

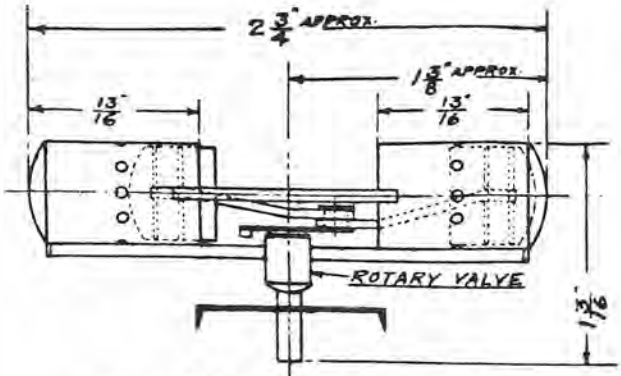
Since these engine designs are over 50 years old, there are some features which could be improved upon. I would suggest a few possible modifications.

1. Omit the auxiliary exhaust holes in the cylinder walls. Experience has shown that with an exhaust valve, the holes are not needed. Also making the holes would not only leave burrs in the cylinder but also would distort the cylinder.
2. Make the cylinders at least 1/8" longer toward the center line of the engine. This will reduce air leakage.
3. Increase the length of the piston by 3/32" so that the piston will just clear the counter balance of the crankthrow. This will reduce air leakage.
4. Omit the holes in the sides of the piston for the wrist pins & omit the wrist pins as drawn. Keeping the center line of the present wrist pin in the same location in the piston (this is important) make a central rivet type of connecting rod pivot. This type of rivet is shown on several other engines described in this book. A steel rod with a hack saw slot in one end will serve as a support when shank or rivet end is peened over in the piston assembly operation. See the Whirlwind, Walker, Hetherington & other engines for this type of connecting rod support. This type of support does not distort the piston as the holes in the side walls of the piston would be certain to do.
5. Make valve shaft & valve sleeve & bearing ALL the same diameter-without a step. This makes it much easier to provide with a close fit & uses less parts. With 2 diameters it is almost impossible to maintain concentricity. This would save air leakage.

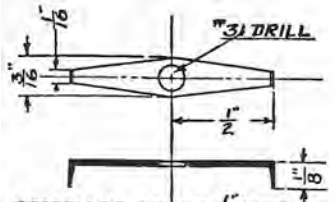
6. Put both intake & exhaust valves on one side of the engine. This will save weight by eliminating one set of pipes & will not waste any air in the process.
7. On the three cylinder engine, arrange the location of the valve ports so that the pipes can be straight. This will save a fancy bending operation & also it will end up making the leakage paths for the air longer & minimize leakage.
8. In the twin engine, extend the valve sleeve & the shaft toward the center line of the cylinders enough so that the offset of the connecting rods will be only half of the thickness of the rods. This will save side thrust force of the pistons on the cylinders & will make a longer leakage path for saving air.
9. Do not retain rods on crank pin with a disk soldered in place. You can't service the engine this way! A better way by far would be to drill a hole near the end of the crank pin & add a washer & wire through the hole to retain the rods & washer in position.
10. If you feel that the cylinders need a brace opposite from the air tubes, I would suggest making a ring from brass sheet 1/32" thick with a 7/8" diameter hole & 1-3/16" outside diameter. Solder this to the cylinders central to the center of the shaft. This will allow the shaft to be removed easily for servicing through the 7/8" hole.
11. There are many better ways of holding the propeller than Mr. Landis has shown. Check some of the other engines & pick one that you like. Personally I like to have the propeller either fold or tilt if it strikes anything. This would save a lot of repairs. Also using the engines as pushers would reduce the incidence of engine & propeller damage.
12. Now with all of these suggestions for improvements add some of your own & why not grab a pencil & paper & draw your engine of the future? I know that you can eliminate quite a few parts & make the parts easier to fabricate. Only a well fitted & timed engine flies the plane which wins the hardware!

An article in an early issue of Model Airplane News by Major H.W.Landis showed a method of manifolding up to 6 Sparklets together to be carried in one model aircraft. The Major believed that the 6 Sparklets would enable the free flight plane to fly for over an hour. Obviously he was a bit over enthusiastic. If it would have flown the hour it would have been lost at any free flight site in the United States.
As shown in the illustration Landis used discarded hypodermic needles with balls inserted as check valves to be penetrated in the Sparklet seals. This device is shown merely as a step in the progress in the use of CO_2 power.



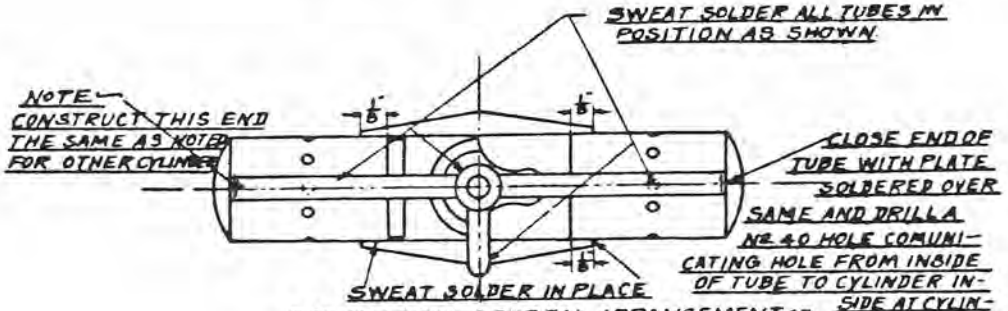


PLAN VIEW GENERAL ARRANGEMENT OF OPPOSED TWO CYLINDER MODEL AIRCRAFT ENGINE.

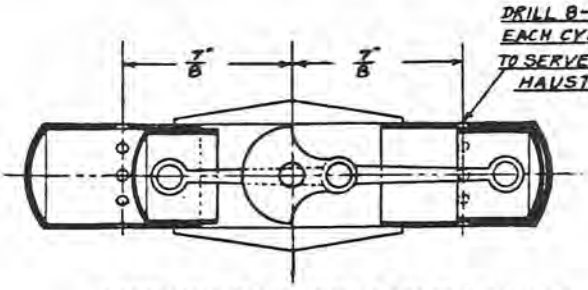


PROPELLER DRIVER. 1/32" SHEET BRASS. ONE REQ. SWEAT SOLDER TO ENG. SHAFT AS SHOWN IN SKETCH No. 10

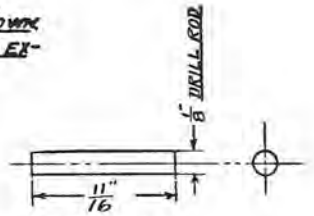
SKETCH No. 17.



FRONT VIEW GENERAL ARRANGEMENT OF OPPOSED TWO CYLINDER MODEL AIRCRAFT MOTOR.

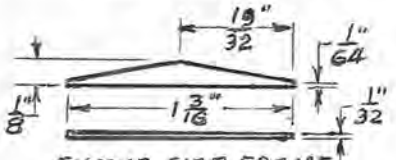


SECTIONAL VIEW—FRONT BEARING REMOVED. OPPOSED TWO CYLINDER MODEL AIRCRAFT ENGINE.



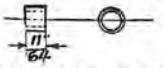
CRANK SHAFT. ONE REQUIRED

SKETCH No. 13.



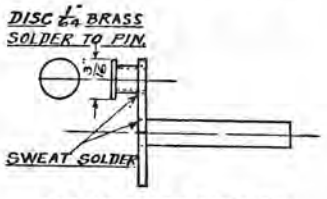
ENGINE SIDE FRAME

SKETCH No. 8



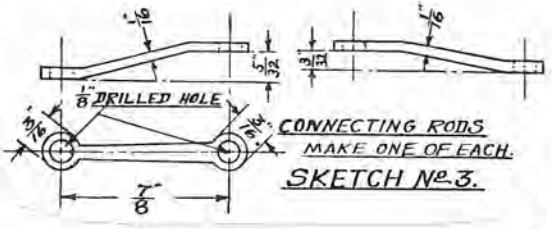
CRANK PIN. ONE REQ. 1/8" BRASS TUBE.

SKETCH No. 14.

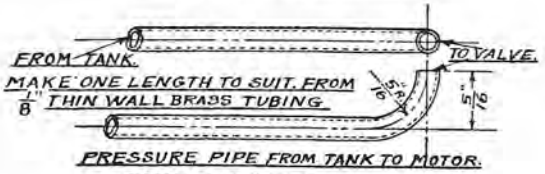


CRANK SHAFT ASSEMBLY

SKETCH No. 15.

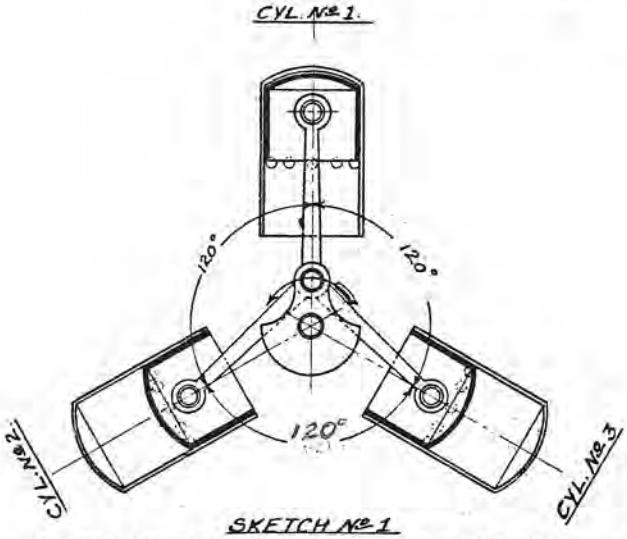


SKETCH No. 3.



PRESSURE PIPE FROM TANK TO MOTOR.

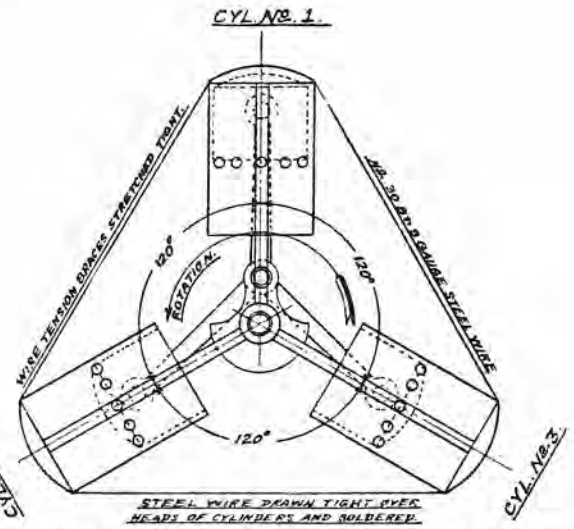
SKETCH No. 5.



SKETCH No. 1

SHOWING GENERAL LAYOUT OF THREE CYLINDER MODEL AIRCRAFT ENGINE.

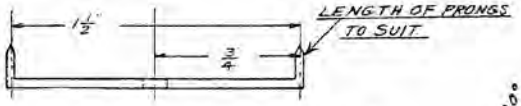
POSITIONS OF CYLINDERS, PISTONS, CONNECTING RODS, WRIST PINS CRANK PIN AND CRANK SHAFT. LOOKING ON MOTOR FRONT.



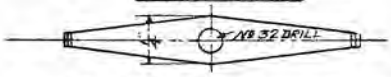
GENERAL ARRANGEMENT OF THREE CYLINDER RADIAL AIRCRAFT ENGINE SHOWING SUPPLY + EXHAUST PIPES ALSO ROTARY VALVES.

SKETCH No. 2.

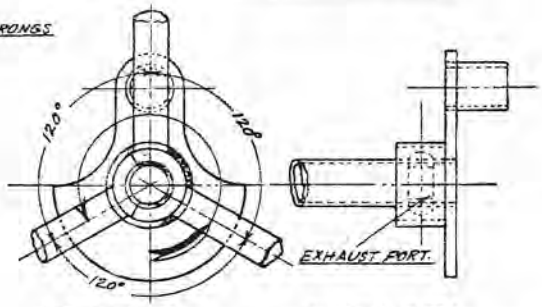
LOOKING ON FRONT SIDE OF MOTOR.



SKETCH No. 56 SHOWING PROPELLER DRIVER. THIS IS OF 1/32 THICK SHEET BRASS

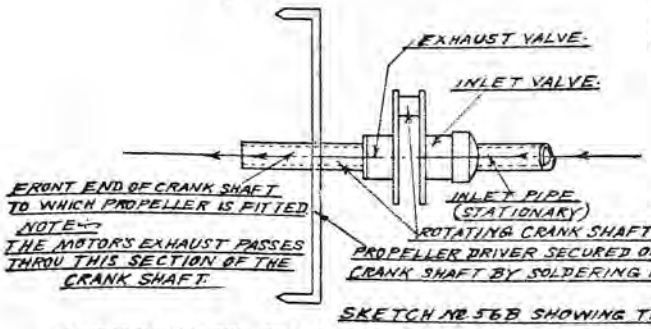


SKETCH No. 56A SHOWING PROPELLER DRIVER (FRONT VIEW).

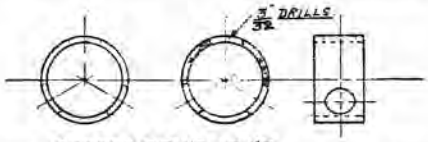


SKETCH No. 58 SKETCH No. 58A.

THIS GROUP SHOWS THE TIMING OF THE EXHAUST VALVE AND THE LOCATION OF THE EXHAUST PORT WITH REFERENCE TO THE CRANK PIN. NOTE – THIS VIEW No. 58 IS LOOKING ON THE FRONT SIDE OF THE MOTOR.

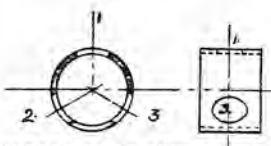


SKETCH No. 56B SHOWING THE ASSEMBLY OF THE PROPELLER DRIVER ON THE FORWARD END OF THE MOTOR CRANK SHAFT. THE OTHER PARTS ARE NOTED TO SHOW THE RELATIVE POSITIONS OF THEM.

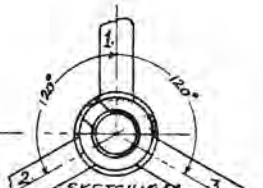


SKETCH GROUP No. 57

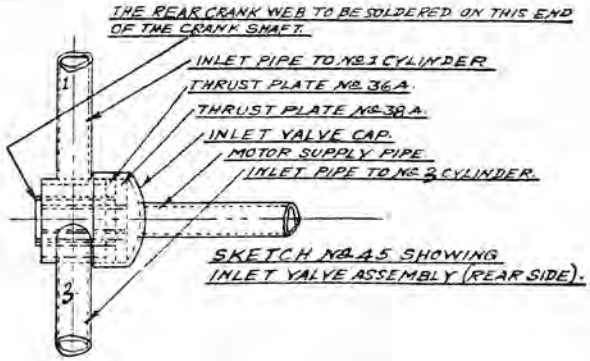
SHOWING THE EXHAUST VALVE CHEST MADE FROM A PIECE OF 3/8 FISHING ROD FERRULE.



SKETCH No. 43 SHOWING THE END SECTIONAL VIEW AND SIDE LONGITUDINAL VIEW OF THE INLET VALVE CHEST AT THE REAR SIDE OF THE ENGINE.

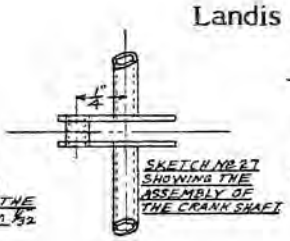


SKETCH No. 44 SHOWING THE INLET VALVE CHEST ASSEMBLED WITH THE INLET PIPES MARKED 1, 2 & 3 AND THE ROTARY INLET VALVE BARREL. (REAR SIDE ONLY).



SKETCH No. 45 SHOWING INLET VALVE ASSEMBLY (REAR SIDE).

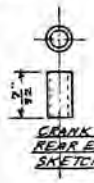
Landis Engine Parts-



SKETCH No. 27 SHOWING THE ASSEMBLY OF THE CRANK SHAFT



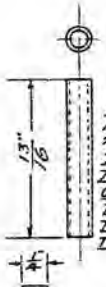
CRANK PIN SKETCH No. 28



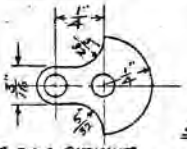
CRANK SHAFT REAR END. SKETCH No. 29.



SKETCH No. 26 SHOWING THE CRANK WEBS FILED FROM 1/32 THICK SHEET BRASS.



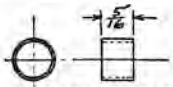
SKETCH No. 30 SHOWING FORWARD END OF 1/8 DIAMETER BRASS TUBULAR CRANK SHAFT THE PROPELLER IS FITTED ON THIS SHAFT AND THE EXHAUST FROM THE ENGINE PASSES THROU IT ALSO.



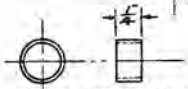
SKETCH No. 26A SHOWING THE CRANK WEBS.



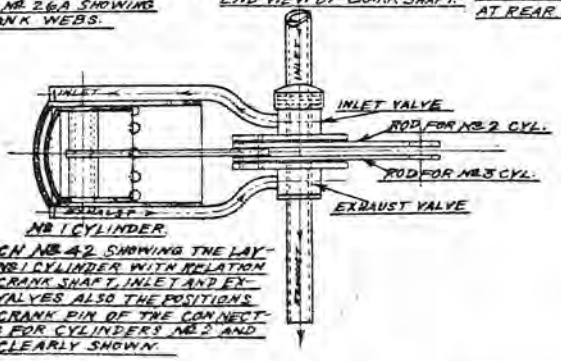
SKETCH 27A END VIEW OF CRANK SHAFT.



SKETCH No. 31 SHOWING THE INLET VALVE CHEST AT REAR SIDE OF MOTOR

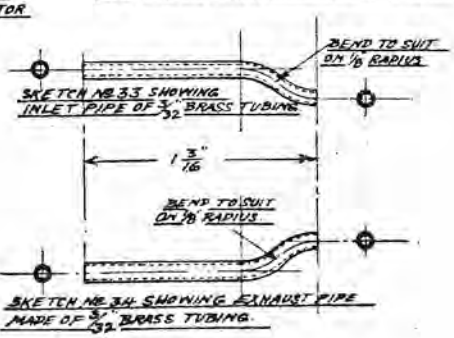


SKETCH No. 32 SHOWING THE EXHAUST VALVE CHEST AT FRONT SIDE OF MOTOR.



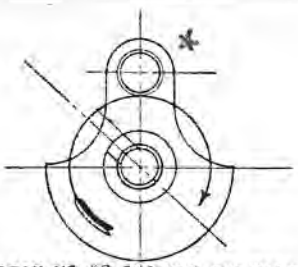
No. 1 CYLINDER.

SKETCH No. 42 SHOWING THE LAY-OUT OF No. 1 CYLINDER WITH RELATION TO THE CRANK SHAFT, INLET AND EXHAUST VALVES ALSO THE POSITIONS ON THE CRANK PIN OF THE CONNECTING RODS FOR CYLINDERS No. 2 AND 3 ARE CLEARLY SHOWN.

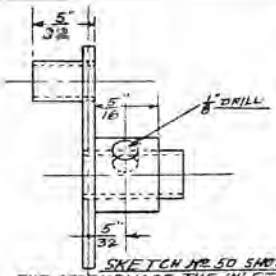


SKETCH No. 33 SHOWING INLET PIPE OF 3/32" BRASS TUBING

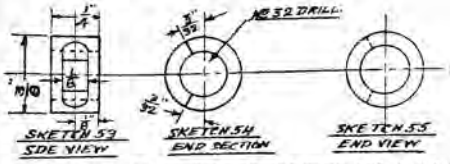
SKETCH No. 34 SHOWING EXHAUST PIPE MADE OF 3/32" BRASS TUBING.



SKETCH No. 49 SHOWING THE INLET VALVE TIMING DIAGRAM WHICH DENOTES THE POSITION OF THE VALVE PORT WITH REFERENCE TO THE CRANK PIN. THIS VIEW IS LOOKING TOWARDS THE FRONT SIDE OF THE ENGINE FROM THE REAR

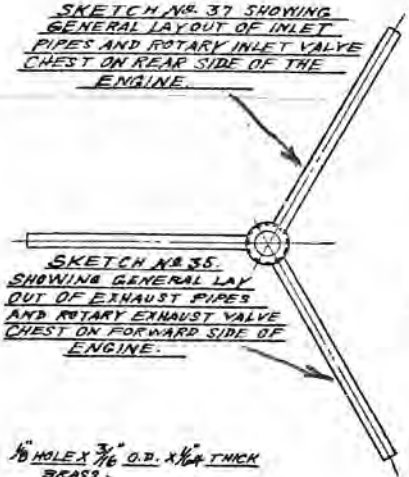


SKETCH No. 50 SHOWING THE ASSEMBLY OF THE INLET VALVE, CRANK WEB, REAR END OF CRANK SHAFT AND THE CRANK PIN.



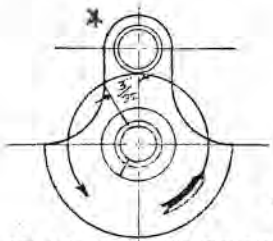
SKETCHES No. 53, 54 & 55 SHOWING THE ALUMINUM EXHAUST VALVE WHICH ACTS ALSO AS THE FORWARD MOTOR BEARING. FOR DIMSIONS OF PORT SEE SKETCH 51

(* ORIGINAL DRAWINGS OF CRANK THROWS ARE OUT OF SCALE. SEE DETAIL #26.)

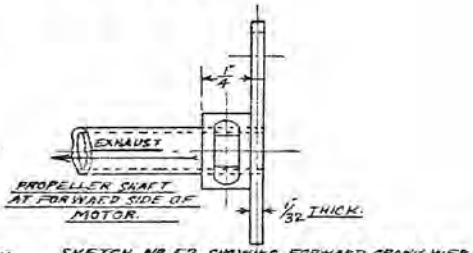


SKETCH No. 37 SHOWING GENERAL LAYOUT OF INLET PIPES AND ROTARY INLET VALVE CHEST ON REAR SIDE OF THE ENGINE.

SKETCH No. 35 SHOWING GENERAL LAY OUT OF EXHAUST PIPES AND ROTARY EXHAUST VALVE CHEST ON FORWARD SIDE OF ENGINE.

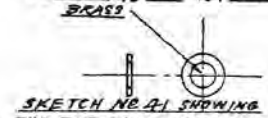


SKETCH No. 51 SHOWING POSITION OF THE EXHAUST VALVE WITH REFERENCE TO THE CRANK PIN. VIEW LOOKING FROM FRONT SIDE TOWARD THE REAR.



SKETCH No. 52 SHOWING FORWARD CRANK WEB PROPELLER SHAFT AND EXHAUST VALVE

1/8" HOLE X 3/16" O.D. X 1/64" THICK BRASS



SKETCH No. 41 SHOWING THE END PLATE COVER AT THE FORWARD OR PROPELLER SIDE OF THE EXHAUST VALVE CHEST. THE PROPELLER SHAFT FITS LOOSELY THROU THE HOLE IN THIS PART.

1/8" HOLE X 3/16" O.D. 1/64 THICK BRASS.

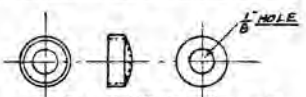


SKETCH No. 38 SHOWING END PLATE ON CRANK SHAFT AT INLET VALVE SIDE THIS IS A THRUST BEARING PLATE AND REVOLVES WITH THE CRANK SHAFT.

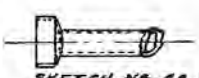
1/8" HOLE X 3/16" O.D. 1/64" THICK BRASS.



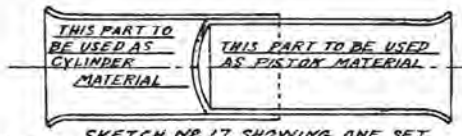
SKETCH No. 36 SHOWING INLET VALVE CHEST REAR COVER 1/32 THICK BRASS WHICH ALSO ACTS AS A STATIONARY THRUST BEARING PLATE.



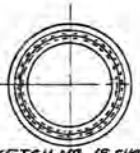
SKETCH No. 39 SHOWING THE REDUCER CAP FOR THE REAR SIDE OF THE INLET VALVE CHEST. CAP MADE FROM FISHING ROD FERRULE



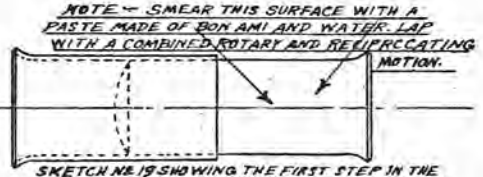
SKETCH No. 40 SHOWING SUPPLY PIPE SOLDERED TO INLET VALVE CHEST COVER COVER SHOWN IN SKETCH No. 39.



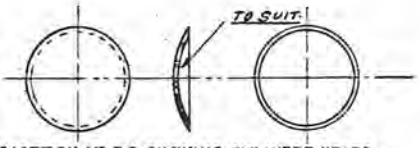
SKETCH No. 17 SHOWING ONE SET OF FISHING ROD FERRULES SIZE 5/32 FROM WHICH PISTONS AND CYLINDERS FOR THE ENGINE ARE EASILY MADE. SEE SKETCH No. 19.



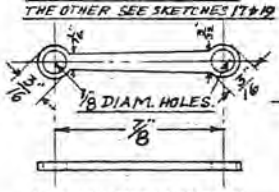
SKETCH No. 18 SHOWING END VIEW OF THE FISHING ROD FERRULES TELESCOPED ONE WITHIN THE OTHER SEE SKETCHES 17 & 19



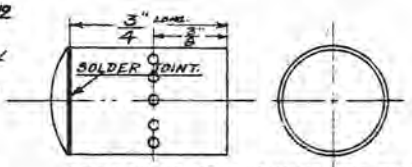
SKETCH No. 19 SHOWING THE FIRST STEP IN THE MANUFACTURE OF A PISTON AND CYLINDER FROM A SET OF FISHING ROD FERRULES OF 5/32" DIAMETER SIZE.



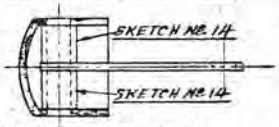
SKETCH No. 20 SHOWING CYLINDER HEADS FORMED FROM 1/64 THICK SHEET BRASS. THIS FORMING CAN EASILY BE DONE BY LAYING THE SHEET BRASS UPON A SOFT PINE WOODEN BLOCK AND STRIKING IT SEVERAL BLOWS WITH THE BALL END OF A MACHINISTS HAMMER UNTIL THE DESIRED CONVEXITY IS OBTAINED.



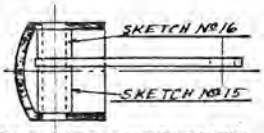
SKETCH No. 21 SHOWING CONNECTING RODS MADE FROM 1/32 THICK HARD ROLLED ALUMINUM SHEET STOCK.



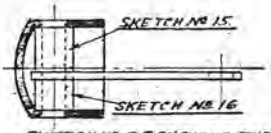
SKETCH No. 22 SHOWING THE SOLDERED JOINT BETWEEN THE CYLINDER AND THE CYLINDER HEAD OF ALL CYLINDERS.



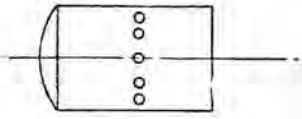
SKETCH No. 23 SHOWING CONNECTING ROD ASSEMBLED ON WRIST PIN IN No. 1 PISTON NOTE THE SPACER TUBES USED.



SKETCH No. 24 SHOWING THE CONNECTING ROD ASSEMBLED ON WRIST PIN IN No. 2 PISTON NOTE THE SPACER TUBES USED.

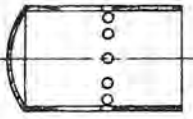


SKETCH No. 25 SHOWING THE CONNECTING ROD ASSEMBLED ON THE WRIST PIN IN No. 3. PISTON. NOTE THE SPACER TUBES USED.



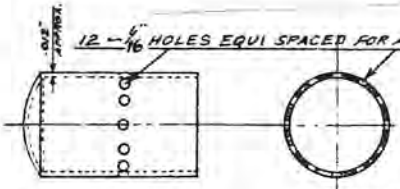
OUTSIDE VIEW OF ENGINE CYLINDER.

SKETCH No. 3.



SECTIONAL VIEW OF ENGINE CYLINDER

SKETCH No. 4

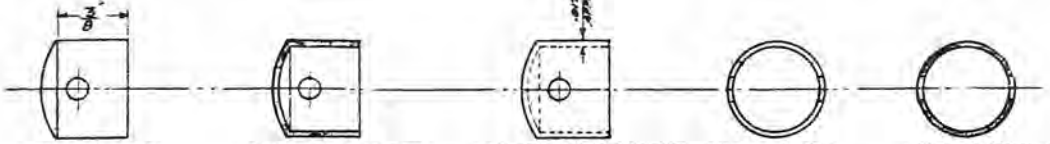


OUTSIDE VIEW SHOWING THICKNESS OF CYLINDER WALLS.

SKETCH No. 5

SECTIONAL END VIEW OF CYLINDER.

SKETCH No. 6



SKETCH No. 7 OUTSIDE VIEW OF PISTON.

SKETCH No. 8 SECTION VIEW OF PISTON

OUTSIDE VIEW SHOWING THICKNESS OF SKIRT. SKETCH No. 9.

SKETCH No. 10 SHOWING END VIEW AND LOCATION OF WRIST PIN HOLES.

SKETCH No. 11. SHOWING SECTION AT WRIST PIN HOLES.



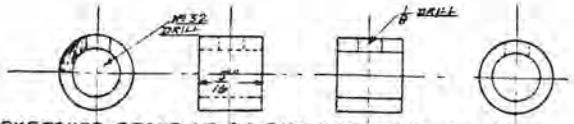
SKETCH No. 12 SHOWING LONGITUDINAL SECTION OF PISTON AT WRIST PIN HOLES

SKETCH No. 13 SHOWING WRIST PIN OF 1/8 DIAM. BRASS TUBING

SKETCH No. 14 SHOWING WRIST PIN SPACER TUBES OF ALUMINIUM.

SKETCH No. 15 SHOWING WRIST PIN SPACER TUBES OF ALUMINIUM.

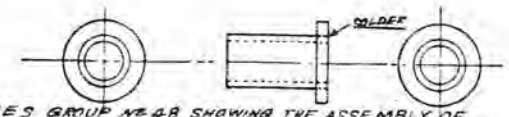
SKETCH No. 16 SHOWING WRIST PIN SPACER TUBES OF ALUMINUM.



SKETCHES GROUP No. 46 SHOWING ALUMINUM INLET VALVE BARREL WHICH SERVES AS REAR MOTOR BEARING



SKETCH No. 47 SHOWING REAR CRANK SHAFT ASSEMBLED WITH THE INLET VALVE BARREL AND THRUST BEARING PLATES.



SKETCHES GROUP No. 48 SHOWING THE ASSEMBLY OF END THRUST PLATE No. 38A ON REAR END OF CRANK SHAFT



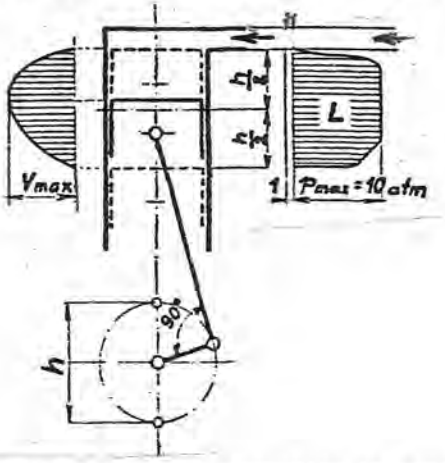
SKETCH No. 36A SHOWING LOOSE THRUST PLATE

SKETCH No. 38A SHOWING TIGHT THRUST PLATE

Czechoslovakian 3 Cylinder Oscillating Expansion Engine.

Please note that the drawing projections are opposite from standard USA practice. This interesting engine is of Czechoslovakian origin in the early 1940s. The scale of the drawing is such that, if a variable ratio copy machine is available, use the 1.22 ratio & the large size of paper. This will make a print with the sizes at full scale. The dimensions are in millimeters & can be converted to inches easily. The size & weight of this engine seem to provide a workable combination which should fly a model aircraft of 4-1/2 to 6 foot wing span.

The engine could be reversed if the intake & exhaust holes were reversed. One direction of rotation is best since the torque tends to tighten the propeller nut. I would strongly suggest that the valve block 7 be lengthened so that there is a rubbing surface about equidistant on each side of the swivel shaft 9. See the dotted lines on the assembly drawing.

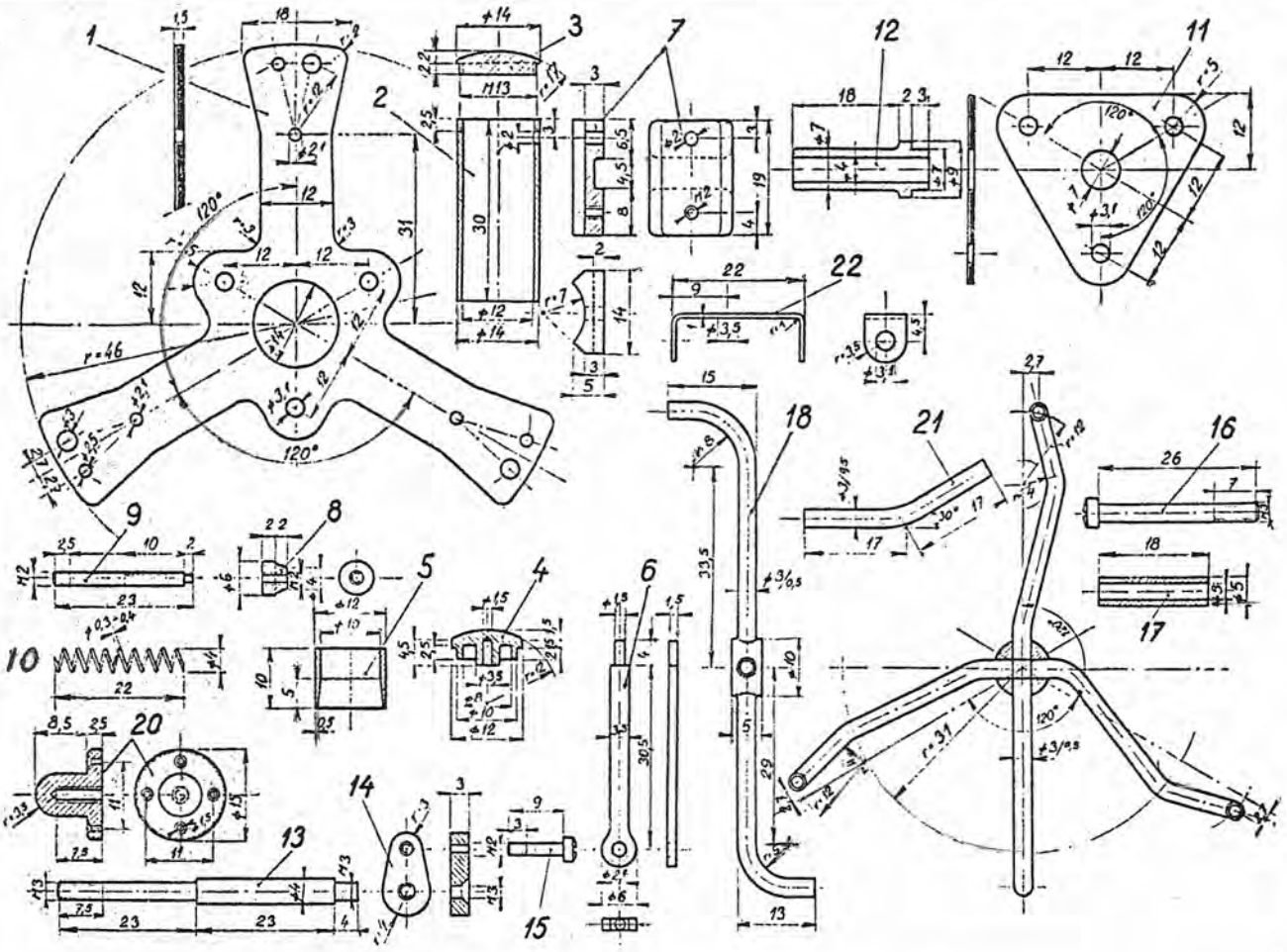


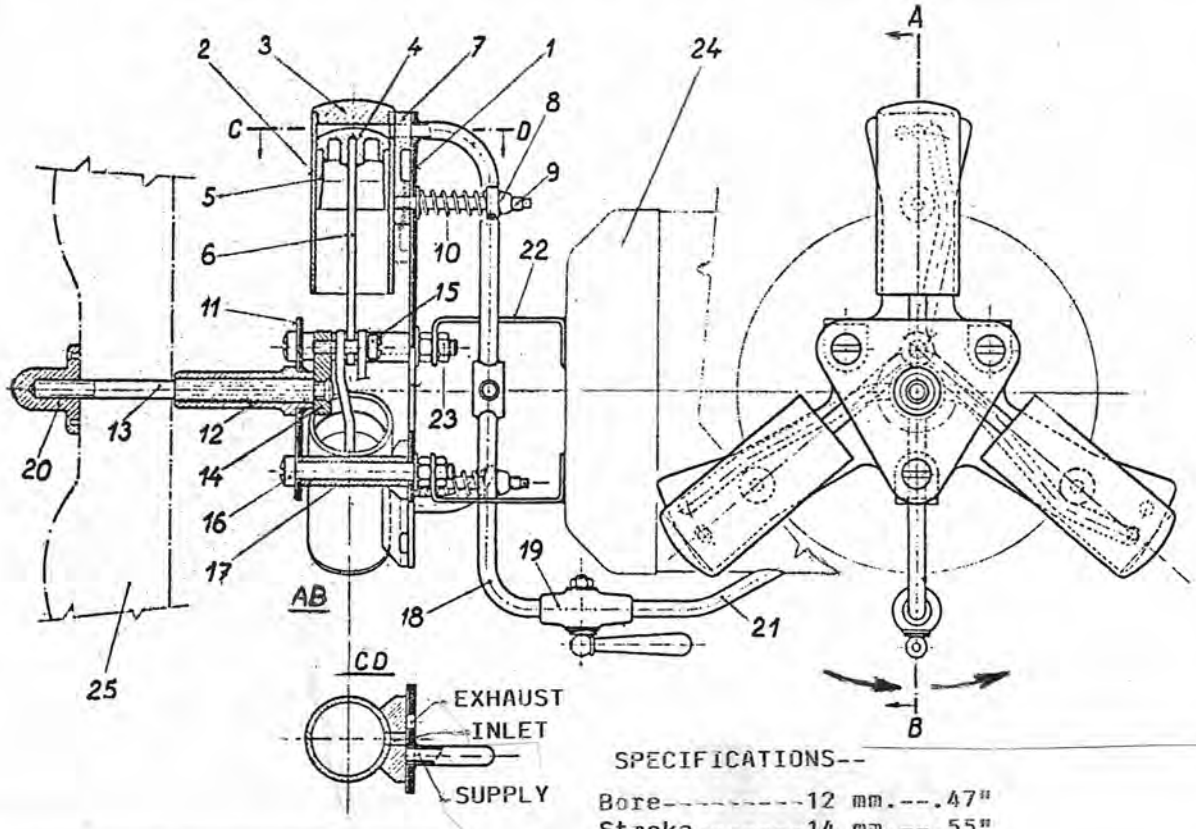
You may elect to make other modifications. For example, a more rigid connection between piston & connecting rod would help alignment. You may wish to place a washer behind the propeller in order to avoid having it pushed over the bearing, part 12. Making the valve holes rectangular would provide more power due to quick intake. Using a different crank pin would make assembly of the connecting rods easier. You would want to connect to the air tank at some other location than in the weak cylindrical shell.

The author of the Czechoslovakian article used the velocity & pressure diagrams to derive some equations of estimated performance. Such calculations on a small engine are interesting. With the many variables in workmanship, friction factors, gas flow turbulence, etc. the results would be different than calculated.

BILL OF MATERIAL

No.	Req'd	Name	Material	Size
1	1	Main frame	sheet brass	.060" x 4" x 4"
2	3	Cylinder	brass tube	1/2" o.d. x .015" wall
3	3	Cylinder head	brass rod	1/2" dia.
4	3	Piston head	brass rod	1/2" dia.
5	3	Piston	brass tube or rod	1/2" dia.
6	3	Connecting rod	brass sheet	.060"
7	3	Valve block	brass	7/32" x 5/8" (see text.)
8	3	Spring retainer	brass or steel rod	1/4" dia.
9	3	Swivel shaft	steel	.079" dia.
10	3	Spring	music wire	.012" to .014" dia.
11	1	Front frame	brass	.060" x 1-1/2" x 1-1/2"
12	1	Bearing	brass rod	3/8" dia.
13	1	Crankshaft	drill rod	3/16" dia.
14	1	Crank arm	steel	1/8" x 5/16" x 5/8"
15	1	Crank pin	steel	7/32" dia.
16	3	Bolt	steel	#4-36 x 1-1/8" long
17	3	Spacers	brass tube	5/32" dia. x .015" wall
18	1	Tube	brass	1/8" dia. x .015" wall
19	1	Throttle valve	brass	
20	1	Propeller nut	dural rod	5/8" dia.
21	1	Tube	brass	1/8" dia. x .015" wall
22	3	Mounting bracket	steel	.040" x 9/32" x 1-1/2"
23	6	Nut	steel	#4-36 hex.
24	1	Tank	brass	2-3/8" dia. x 39-3/8" long
25	1	Propeller	wood	13-3/4" dia. x 10-1/4" pitch





SPECIFICATIONS--

Bore----------12 mm.--.47"
Stroke--------14 mm.--.55"
Speed---------- 1260 r.p.m.
Weight--------70 gm.-2.46 oz.
Propeller----250 mm.13-3/4"dia.
Max.pressures-10 atmos.-147 p.s.i.

Mr. Ming S. Kwei's Rotary COMPRESSED AIR Motor

These drawings of Mr. Kwei's rotary engine appeared in 1931. As we know, rotaries have propeller attached to crankcase & entire engine revolves around a stationary crankshaft. Mr. Kwei studied a great amount of data on compressed air & other expansion engines. Kwei tried a French CO_2 engine. He felt that weight of this power plant with its hot water bottle to prevent dry ice from forming was excessive for a good flying model airplane. Compressed air was settled upon as being much lighter & more simple. This is the engine which he finally designed & built.

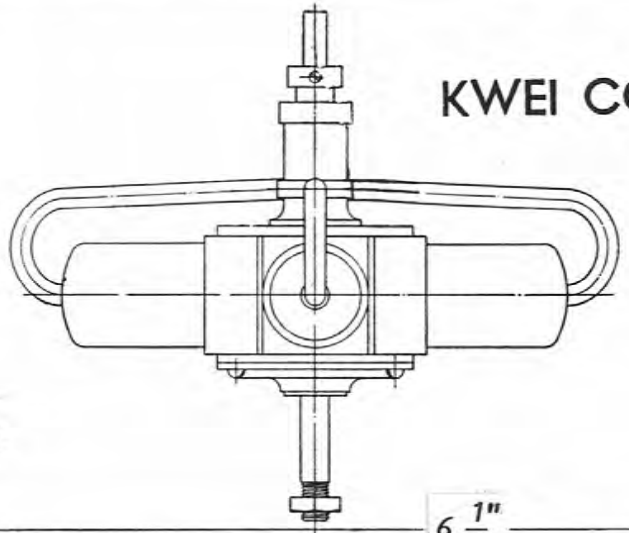
Plans have been enlarged from published 1931 plans yet some of dimensions are still too small to be read easily. Some of major dimensions will be reviewed to assist any builders. Bore is .743"; stroke is 3/4"; hollow propeller shaft is 1/4" diameter with 1/4"-28 thread 3/8" long; 1-3/4" hexagonal aluminum crankcase is bored 1-17/32" diameter to a depth of 1-3/32". Cylinders insert into crankcase 3/16". Cylinders are bored to depth of 1-9/16". Piston is 3/4" long & bored 21/32" diameter & 21/32" deep. Feed pipes to cylinders are thin wall brass & 3/16" diameter. Steel crank stud is 1/2" long & threaded #2-56. Brass crank is .045" x 7/32" wide x 5/8" long. Valve housing is bronze 1-5/32" long & bored 1/2" diameter for full length. Brass connecting rods are 1-1/2" between holes. Spacers hold rods central in pistons. Two of connecting rods are offset on opposite sides of one straight rod. Part #11 was not drawn. Note that exhaust is through 3 slots 1/16" wide & 60° apart in valve part #12 & through holes (6) in valve housing cap part #14. See end views. Draftsman who made original plans was inept. For example width of steel retaining clips for cylinders are too narrow to serve that purpose. Clips should be at least 1/4" wide in center but may be tapered toward ends. Offset in connecting rods is also suspect. End of rods with larger hole needs to have larger radius. However if you like rotary engines you may wish to make needed drawing checks & modifications before cutting metal.

Mr. Kwei fitted parts so well that by rotating engine backwards 100 turns pumped sufficient air into tank to give back 75 turns. Considering the air is handled twice, this is a high efficiency. Kwei made some power tests & calculations which should be of interest. In test runs of 30 seconds duration average pressure, called mean effective pressure (M.E.P.), was approximately 50 psi. With a piston area of .434 sq. inches & using formula HP=2 nrpa/33,000 Mr. Kwei arrived at a figure of .251 HP. However with an estimated efficiency of 40% this reduces probable horsepower to .10 HP. This .10 HP. was used in balance of calculations for his model plane. His throttle valve construction is very simple & easy to make. A #2 taper pin 1-1/4" long is carefully lapped with a hole in valve body which has been reamed with a #2 taper reamer. Do not drill cross wise hole until lap appears to be 100% on each surface. After drilling cross hole through both pieces together, remove any burr left by drill. When finished, valve should be "bubble tight", that is, no bubble should show when pressure is applied to valve either open or closed. Tallow is best lubricant for this type of valve. Bees' wax may be used. A modification of Kwei's valve to prevent loss & maintain snug fit of stem in body, is suggested. Drill a small hole in stem leaving room for a washer & several turns of a coil spring. Washer & spring may be retained by a wire through hole in stem or a snap ring fitted into a groove made in stem.

Some weight may be shaved from Kwei's 7.15 ounces. Cylinder head thickness shown as 1/8" may be reduced to 1/16" or even 3/64" Holes may be made in crankcase to save weight. Air pipes would be adequate if made from 5/32" x .014 wall brass tube. With a motor involving many hours of careful work you should consider installing it in a pusher type of model in order to better protect the motor from harm. If motor is installed in a tractor type of model, a stall followed by a nose dive would probably do considerable damage.

Mr. Kwei gave a minimum size of model which he believed would be required for this powerplant. A wing span of 6 feet & a chord of 12" was suggested. He calculated that this would make the wing loading approximately 9 ounces per square foot. A lighter wing loading would be better.

KWEI COMPRESSED AIR ROTARY MOTOR

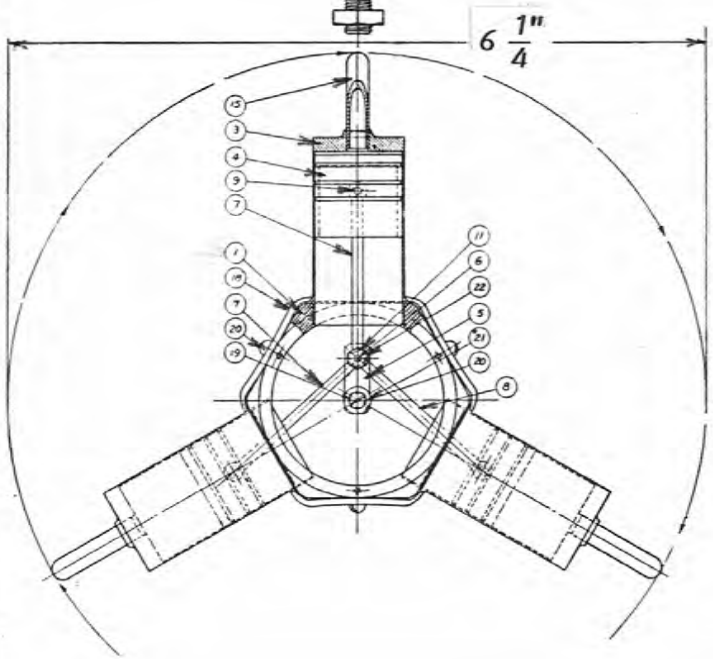


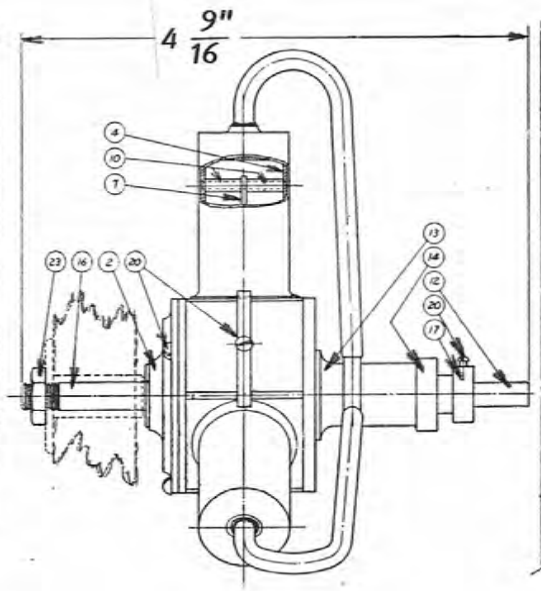
SCALE-INCHES

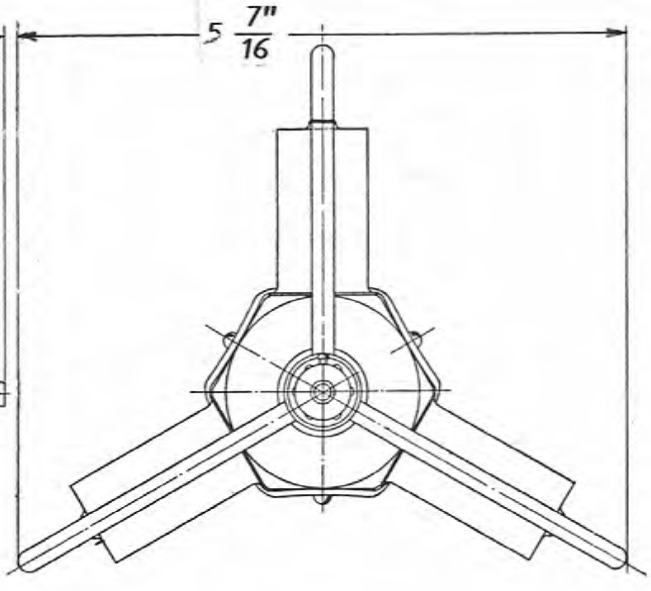
4 3 2 1 0

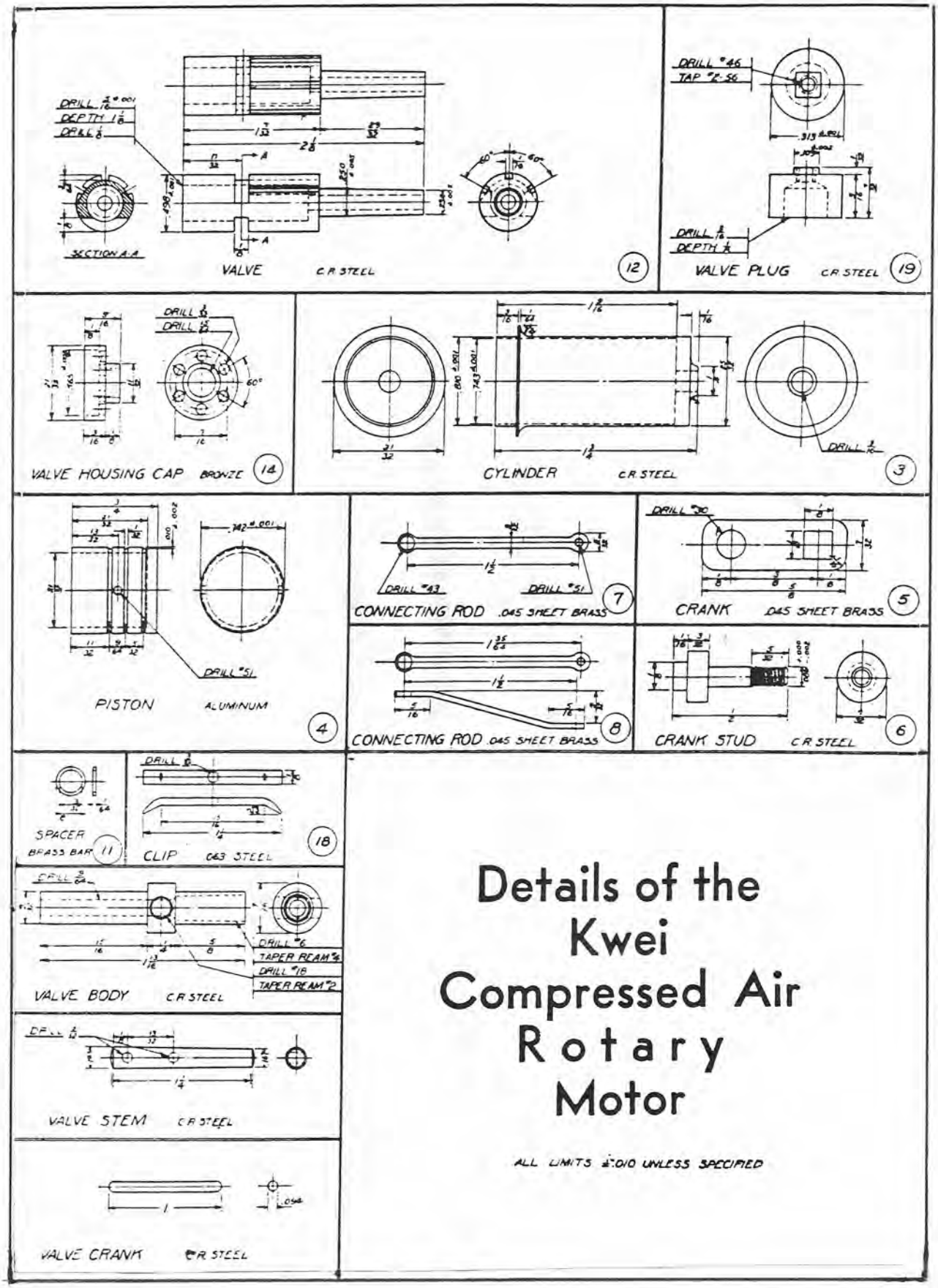
PART NO.	PART NAME	NO. REQD
1	CRANK CASE	1
2	COVER PLATE	1
3	CYLINDER	3
4	PISTON	3
5	CRANK	1
6	CRANK STUD	1
7	CONNECTING ROD-STRAIGHT	2
8	CONNECTING ROD-OFFSET	1
9	WRIST PIN	3
10	CONNECTING ROD SPACERS	6
11	SPACERS ON CRANK STUD	2
12	VALVE	1
13	VALVE HOUSING	1
14	VALVE HOUSING CAP	1
15	AIR LEADS	3
16	PROPELLER SHAFT	1
17	COLLAR	1
18	HOLDING CLIP FOR CYLINDER	3
19	VALVE PLUG	1
20	#2-56 × 1/8 RD. HD. STEEL MACH. SCREW	8
21	#15 COPPER BUR	1
22	#2-56 HEX. BRASS NUT	1
23	1/4-28 HEX. STEEL NUT	1

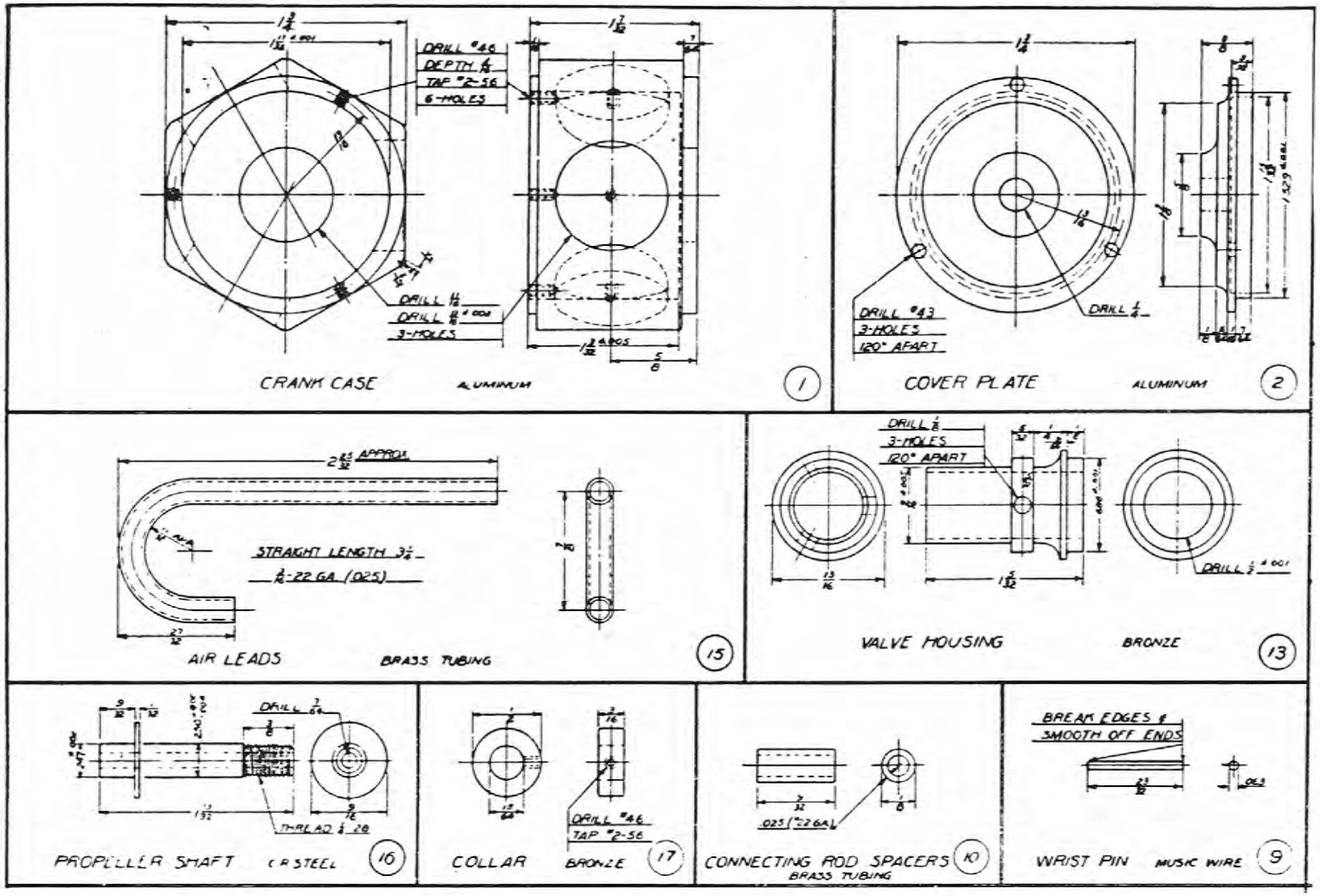
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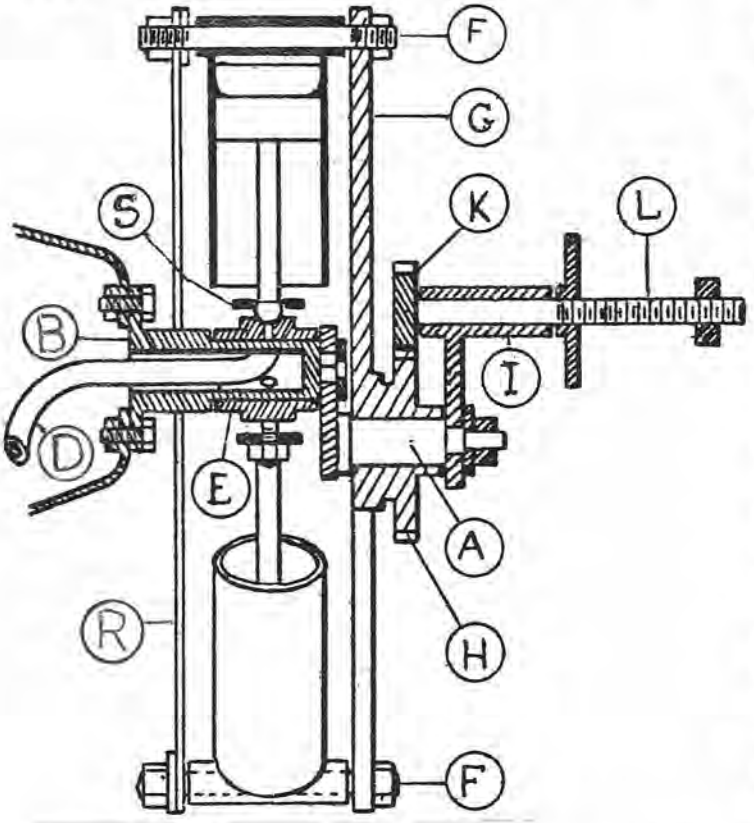



VALVE C.R. STEEL 12
VALVE PLUG C.R. STEEL 19
VALVE HOUSING CAP BRONZE 14
CYLINDER C.R. STEEL 3
PISTON ALUMINUM 4
CONNECTING ROD .045 SHEET BRASS 7
CRANK .045 SHEET BRASS 5
CONNECTING ROD .045 SHEET BRASS 8
CRANK STUD C.R. STEEL 6
SPACER BRASS BAR 11
CLIP .063 STEEL 18
VALVE BODY C.R. STEEL
VALVE STEM C.R. STEEL
VALVE CRANK C.R. STEEL
Details of the Kwei Compressed Air Rotary Motor
ALL LIMITS ±.010 UNLESS SPECIFIED


DRILL #46
DEPTH 1/8
TAP #2-56
6-HOLES
DRILL 11/16
DRILL 11/16 +.001
3-HOLES
CRANK CASE
ALUMINUM
1
DRILL #43
3-HOLES
120° APART
DRILL 1/4
COVER PLATE
ALUMINUM
2
STRAIGHT LENGTH 3 1/4
1/16-22 GA. (.025)
AIR LEADS
BRASS TUBING
15
DRILL 1/8
3-HOLES
120° APART
DRILL 1/2 +.001
VALVE HOUSING
BRONZE
13
DRILL 7/64
THREAD 1/4-28
PROPELLER SHAFT
C R STEEL
16
DRILL #46
TAP #2-56
COLLAR
BRONZE
17
.025 (#22 GA.)
CONNECTING ROD SPACERS
BRASS TUBING
10
BREAK EDGES &
SMOOTH OFF ENDS
WRIST PIN
MUSIC WIRE
9

French "Rube Goldberg" Expansion Engine-Rotary-Geared-by M. Comby.

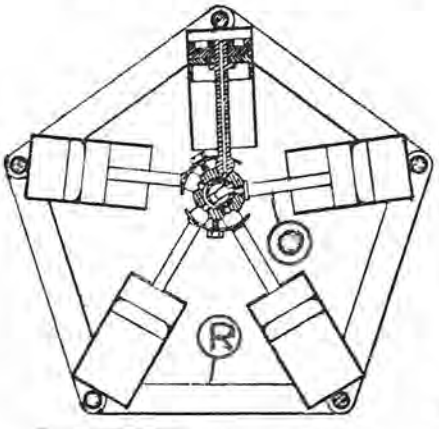
I believe that the best way to describe this odd-ball engine would be to tell which parts do not move. In the drawing, parts which do not move are (A), (B), (D), & (I).

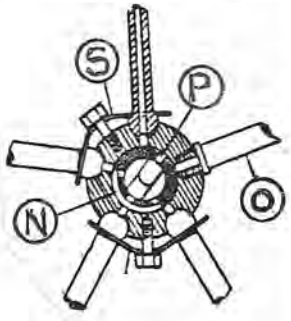


The cylinders oscillate about the threaded shafts (F). There are 5 cylinders. They are attached to the frame (G). The frame (G) has a gear, (H), integral with it. The gear & frame rotate about the shaft (A), which is stationary. As the gear rotates, it drives a smaller gear & shaft (K) & (L) to which the propeller is mounted.

The pistons are equipped with cup washers. Note that the ends of the connecting rods at the center piece (E), which is also the valve,are hemispherical, all but one. That one is screwed rigidly to the valve & bearing (E) much like a master rod. All of the connecting rods are hollow & feed the air in out in proper time. The 4 connecting rods which swivel, are retained in their sockets by 2 springs (S) which allow a slight motion in the socket without air leakage.

This is the same engine which Gamages advertisement, shown elsewhere in this book, displays. There are several gear drive engines but this one seemed to be the most interesting in design & operation. The smaller views should assist in explaining the arrangement of the hollow connecting rods & the spring retainers. The valving & the master rod are shown on the smaller of the two sketches.





The rod (O) is the master rod. The springs (S) are shown more clearly in the smaller of the two sketches. The pipe (D) is the intake & the recess (N) in the stationary shaft (B) is the exhaust. The exhaust air or gas leaves the engine to the left through the hole in (B) that the air inlet tube (D) enters. When the hole (P) is aligned with a hollow connecting rod orifice, that cylinder becomes pressurized. The slight tilting of the connecting rods of 4 of the cylinders does not affect the timing of the engine since the holes in (E) are fixed & do not shift. The shifting of the master rod as that cylinder oscillates does have a small effect upon the timing of the other cylinders. The intake tube (D) connects to hole (P) in shaft (B).

The frame bars (R) on the rear of the engine appear to be separate pieces. Due to the high forces generated by this type of engine, these 5 bars should either be soldered together or cut from a sheet in one piece using (G) as a pattern.

This engine should prove to be an interesting project for the mechanically inclined!

COMPRESSED AIR Engines of the Miniature Aircraft Corporation

Mr. Kenneth Pouch of New Brighton, New York engaged in the manufacture & sale of deluxe model aircraft items including a line of three COMPRESSED AIR engines. His engines were very attractive & well made. The shaft was made of steel. Other than the valve & air tube the rest of the motor was made of aluminum alloy. The cylinders all had shallow fins for appearance sake-"-to make them look like real engines". All 3 engines were of the radial type. Cylinders are mounted radially on a cylindrical crank case. Crankshafts on all 3 are counterbalanced. The propeller shaft projects from the front of the crank case cover. The propeller shaft has a flange which drives the propeller in the same manner as in full size engines.

The quantities of these engines which were produced is not known. However a few of these engines have been found in swap shops, collectos & flea markets. I have had pictures of these engines sent to me for identification purposes. A recent picture of a six cylinder engine was received from a man in Michigan.

Mr. Pouch called his 4 cylinder engine the "Special". The 6 cylinder job came up with the name of "Challenger". These names are from his 1932 catalog. He did not get around to naming the 8 cylinder in this catalog.

Mr. Pouch purchased seamless brass tanks from the Peru Model Airplane Shop of which I was the owner. The tank sizes he used with the engines were 2-1/2" diameter x 22" long; 3" diameter x 22" long; & 3-1/2" diameter x 22" long. He had the best tanks which were available at that time!

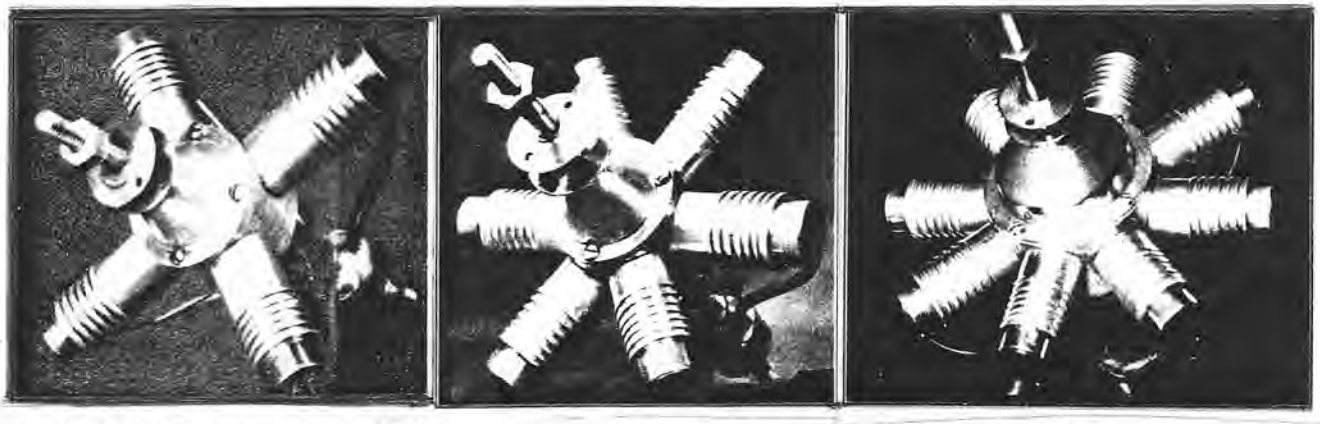
Engine specifications:

No. cylinders	4	6	8
Bore & stroke	3/8" x 3/8"	3/8" x 3/8"	3/8" x 3/8"
Diameter overall	3-1/4"	3-1/2"	4-1/4"
Weight bare	2-1/4 oz.	3-1/2 oz.	5-1/2 oz.
Horse power	1/10	1/6	1/5
Propeller diameter	14"	16"	18"
Model size, span	4'-6'	6'-7'	7'-8'

Mr. Pouch's 1932 catalog lists 15 attributes all to be found exclusively in his very fine engines. He states "Our new COMPRESSED AIR motors specially designed for model aircraft are the result of many experiments with every known type of air motor. Tests show these motors will last indefinitely, are almost unbreakable, and develop more horsepower & revolutions per ounce of weight than any known motors. They have stood a 24 hour endurance test at full speed without sign of wear or trouble."

Since the name of the game has become light weight, lots of air & abundant power, these engines would qualify to fly models of light weight in the range of wing spans specified.

This radial motor is mounted at the rear similar to a rotary engine. Thus it has a big cantilever overhang making it more easily subject to crash damage.



-and this is what they look like. They certainly should be collectors' items! A radial engine which has the appearance of a rotary engine is unique. The air valve chamber even looks like the valves generally used on a rotary engine.

The Butterworth COMPRESSED AIR Engine.

The COMPRESSED AIR engine appears similar to a 4 cylinder automobile engine rather than a model aircraft power plant. However it is a very powerful little gem from 1920.

The overhead valve is a unique feature which conserves air since there are no pipes between the valve shaft & the cylinders. The half speed valve shaft is necessary because the valve shaft holes are drilled through & operate at each 180° of rotation. The mounting means is apparently by the extension of the front & rear bearing brackets.

The weight of the engine is only 4-1/2 ounces & can be reduced somewhat. The 3/8" bore & 1/2" stroke provide ample power to drive 12" to 15" diameter propellers.

Let us see how the engine is made. Mr. Butterworth turned the cylinders from 5/8" diameter steel rod. The lower end of the cylinders is threaded with 1/2"-40 thread. The cross holes in the cylinder head for the valve shaft are first drilled with a #13 (.185" dia.) drill & reamed with a 3/16" dia. reamer to fit the valve shaft. For drilling the angled intake & exhaust holes, Butterworth made a special angled fixture. See Fig.6. A 3/8" dia. pin mounted on a block at a 45° angle was used to set the cylinders on for this operation. These 5/64" dia. holes should just meet with the two 1/8" dia. x 1/16" deep holes as shown in the end view of the cylinder. The 4" long valve shaft is turned from 3/16" dia. drill rod. Drill the 5/64" dia. holes exactly as shown in the drawing. Remove any fine burrs so that the shaft fits the cylinder holes closely but without binding.

The crankshaft is built up on a 6-1/4" length of 1/8" dia. drill rod. One end is threaded #5-40 for 3/4" length. Crank webs are made of 3/16" x 1/4" steel. Drill all webs alike using the first one as a drill jig for the other 7 pieces. Since the connecting rods may catch or rub the webs it is suggested that a small diameter shoulder perhaps 1/64" high be turned around the crank pin hole of each web to avoid the problem. Locate the webs & crank pins very accurately both lengthwise & angularly. Tack solder all in position & recheck the locations. Then drill & pin all 16 places with 1/32" dia. pins. Secure the pins with a touch of solder. Now resolder all joints without getting any solder on the bearing surfaces. Then using a fine tooth jewellers saw & a file, remove the short piece of main shaft between each crank web neatly. Wash off flux in hot water; & oil to prevent rust.

The shaft bearings are brass or bronze. The end bearings are shown in Fig. 2. The center bearing is made of 2 pieces so that it can be assembled. Solder the two pieces together while making this center bearing. The center bearing does not have the 1/4" dia. end shoulders, making it only 3/8" long. The bearing supports are bent from 1/16" x 1/4" steel strip. All supports must be the same height exactly so that the shaft holes will be in alignment.

The backbone of the engine is the steel channel made from 1/16" flat stock. Since it is difficult to bend narrow flanges it may help to make the flanges wider & cut them to 3/16" height overall. Mark out the cylinder holes accurately & make them after bending the flanges. The base must be flat for all parts to fit properly.

The bevel gear on the valve shaft is 3/4" in diameter, mating with a 3/8" pitch dia. of the set. The crankshaft bevel gear should be a pair of 3/8" pitch dia. miter gears. You may have to bush the 3/4" dia. gear hole as the standard size is 3/16". The gear & shafting support bracket is made of 1/16" x 1/4" steel strip. After the gears are aligned properly to run freely, they should be tack soldered & then pinned with 1/32" dia. pins.

Butterworth did not specify the material used for the pistons. Aluminum alloy is suggested for lightness although brass would be satisfactory. Lap fit the pistons to the cylinders & keep in marked pairs. Connecting rods are made of steel or brass 1/8" thick. Fasten the rod cap temporarily & drill for 1/8" reamer. Keep in pairs with markings.

The cylinders are fastened to the base channel with ring nuts threaded 1/2"-40. He shows an alternate method in Fig. 5 of clamping the cylinder instead of the rings in Fig. #1

All screws used are #2-56 thread.
If difficulty is experienced in entering the valve shaft in all cylinders, it is suggested that the two center ring nuts be loosened several turns. Then slightly loosen the end ring nuts. Now the valve shaft should be inserted through all cylinders. The valve shaft serves to align all of the cylinders. The cylinders can all be soldered on the top side & the ring nuts removed entirely.
In order to complete the engine we need a #5-40 shaft nut & a propeller flange. The flange may be made of aluminum alloy. It is pinned to the shaft with just a few .001" end play with the bearing bushing. Now with a little fine oil the engine may run with air pressure. If it is too stiff to run, hold the shaft in the lathe or drill press chuck & run for a minute or two with plenty of oil. This should free the engine sufficiently for it to run with air if the valve timing is correct.
Since blind holes are difficult to finish & lap & fit pistons into, you may wish to try making the cylinder in two pieces, an open cylinder of thin wall & a cylinder head which slips over the cylinder & is soldered in place after the piston is lap fitted. Also a wider hole in the cylinder head for the valve shaft with a corresponding increase in the mating shaft portion could eliminate the need for the packing & the packing grooves. A close fit over a greater length, when oiled before each flight, will not leak much air. We know how to align the cylinders for soldering in place so there should be no problem of alignment of the close fitting shaft & cylinder heads. Adding up two sets of numbers, the pistons have too great a clearance with the top of the cylinders. With the two piece cylinders & the shaft alignment scheme we can arrange for the pistons to barely clear the cylinder heads by using a paper disc in the end cylinders. With the cylinders lined up on the valve shaft insert the pistons. With one end crank at top dead center push the cylinder down until the piston contacts the paper disc. Tack solder that cylinder to the channel base. Then do the same with the other end cylinder & piston. Drift out the rod cap pins & take out the paper discs. Solder all cylinders securely on the top side & reassemble the pistons. You have prevented the waste of a 1/8" high cylinder of air at each stroke. This adds up to a considerable increase in flight duration.
All steel flat stock could be reduced in thickness to #18 ga. (.0478") at least, saving nearly 24% of the weight of these pieces.
If the bevel gears do not appeal to you a set of 3 plain spur gears of fine pitch-32 or 48- 3/4" pitch diameter & one 3/8" pitch diameter gear for the crankshaft will do the job. The gears center lines can be staggered slightly as required to fit the center line distance between the two shafts. The 2 center gears are idlers & they do need to be pinned to the shafts merely to retain the shaft in the gear.
The drawings have been "blown up" from a smaller drawing to full size.

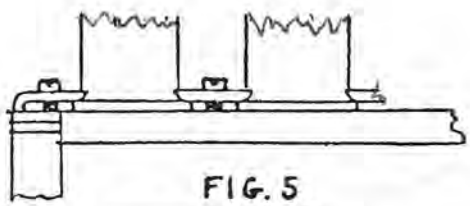


FIG. 5

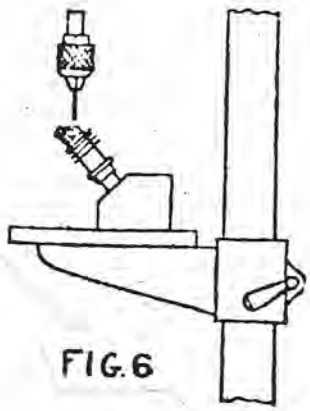
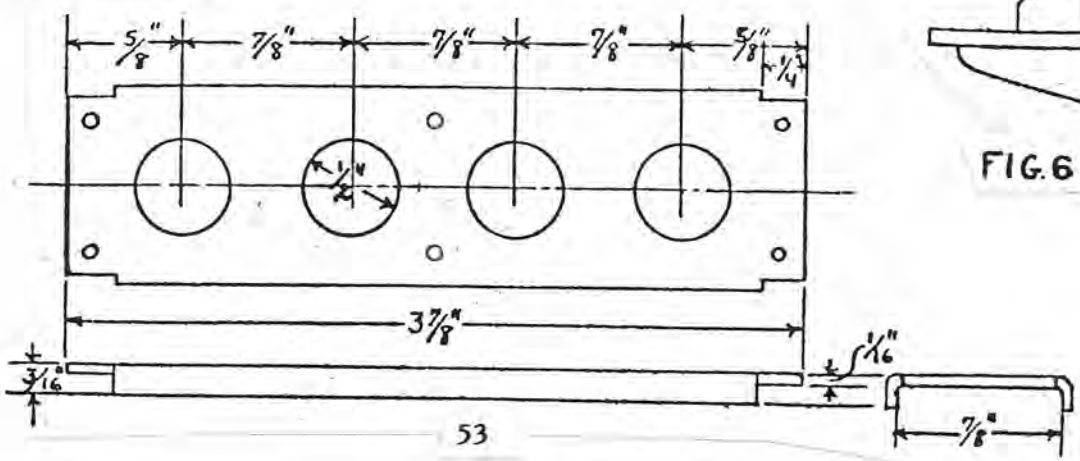
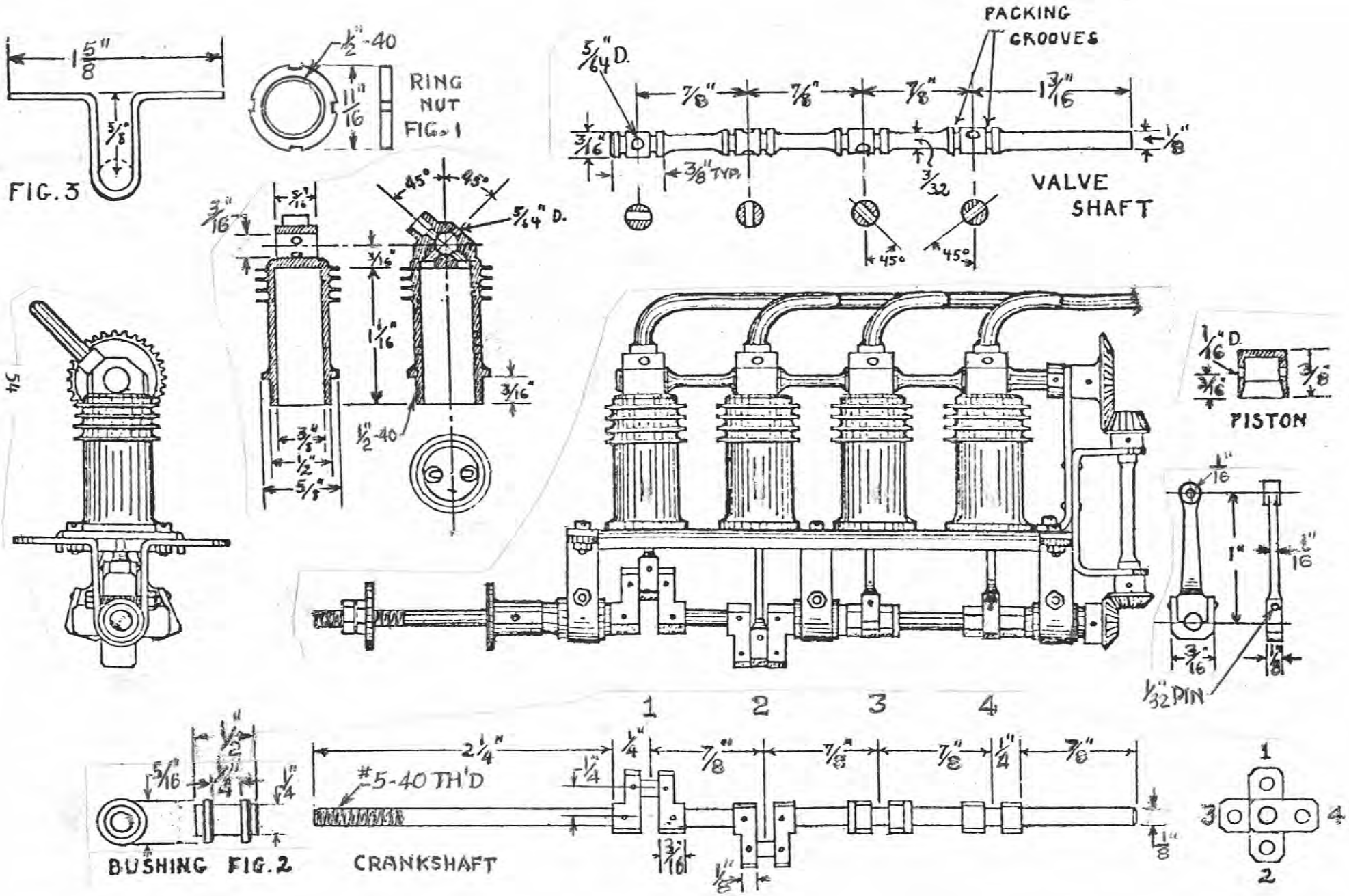


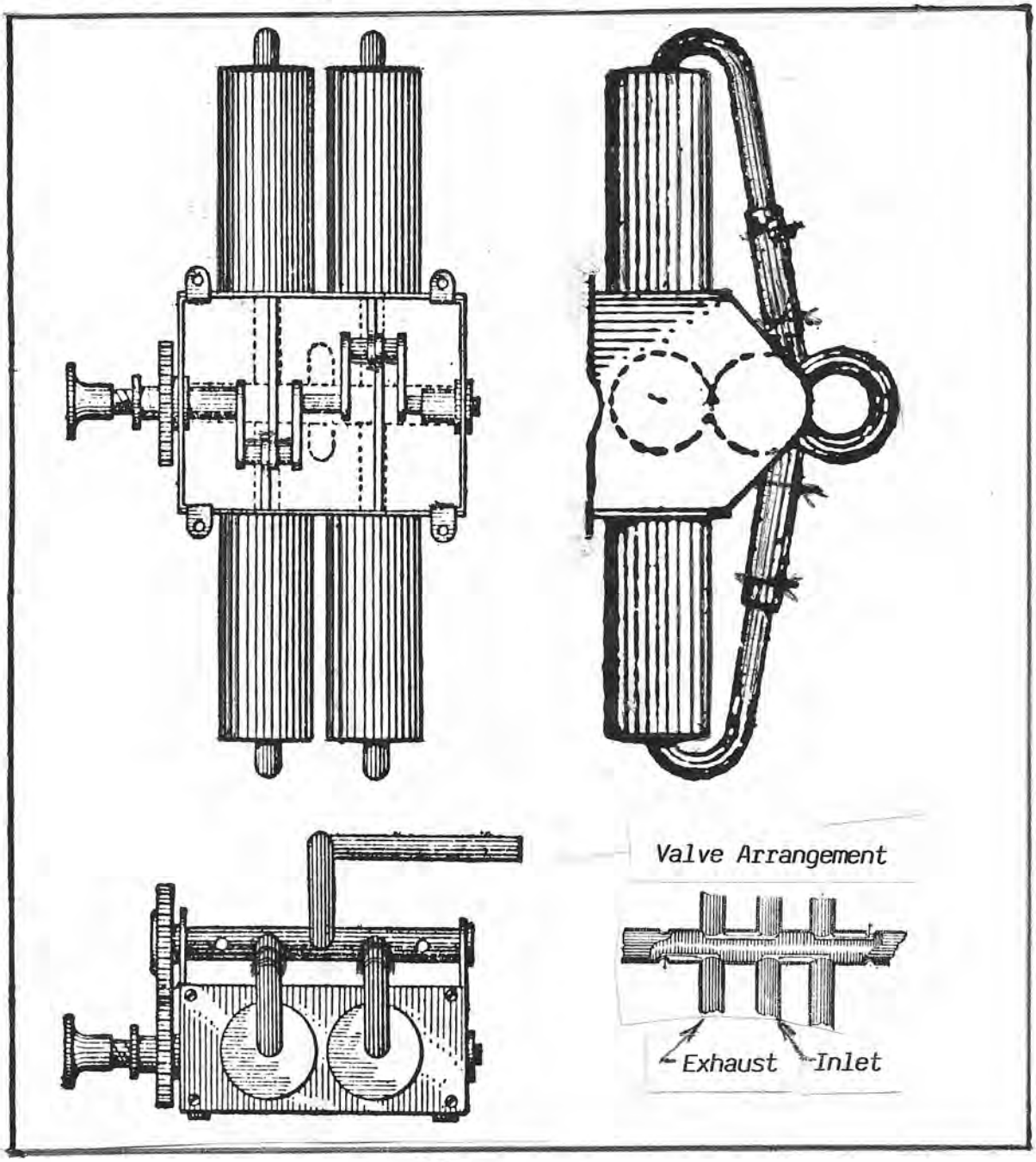
FIG. 6




1 5/8"
5/8"
FIG. 3
1/2"-40
11/16"
RING NUT FIG. 1
PACKING GROOVES
5/64" D.
7/8"
7/8"
7/8"
1 3/16"
3/16"
3/8" TYP.
3/32
1/8"
45°
45°
VALVE SHAFT
3/16"
5/16"
45°
45°
5/64" D.
3/16"
1 1/16"
3/16"
1/2"-40
3/8"
1/2"
5/8"
1/16" D.
3/16"
3/8"
PISTON
1/16"
1"
1/16"
3/16"
1/8"
1/32" PIN
1
2
3
4
1/2"
5/16"
1/4"
1/4"
BUSHING FIG. 2
2 1/4"
#5-40 TH'D
1/4"
1/4"
7/8"
7/8"
7/8"
1/4"
7/8"
3/16"
1/8"
1/8"
CRANKSHAFT
1
3
4
2

Frank Schober 4 Cylinder Opposed COMPRESSED AIR Engine.

Drawing below is full size of a most unique 'flat four' COMPRESSED AIR engine built in 1915. Bore & stroke were 1/2". Crankcase was made with 4 pieces of .020" thick spring brass. End pieces support valve sleeve & shaft at a proper center distance for equal size gears to mesh properly. Side pieces support brass cylinders. Stainless cylinders would be better today. Red fiber was used to make pistons. Aluminum pistons lapped in cylinders would be a better combination. Valve shaft & sleeve should be lapped to close fit. Timing is adjustable by changing mesh of gear teeth. Crankshaft was made with steel for shaft & brass for webs. Side plates with cylinders were removable in original engine in order to assemble pistons. Crankshaft bearings in end plates were steel in original Schober engine. Timing is shown by a section of valve & sleeve. Diagonally opposed cylinders "fire" simultaneously making only 2 power pulses per revolution. Placing pairs of cylinders at 90° to each other would make 4 power pulses per revolution & would always be in a position to start. When properly constructed with care this little gem will swing a 17" diameter propeller at a lively clip.



Hetherington COMPRESSED AIR Engine

Robert Hetherington's engine story was researched by John Brown & appeared in his "Wind Mills" column of Timothy J. Dannel's Engine Collectors' Journal issue #39-1971. Since about 100 of Hetherington's aluminum 3 cylinder radial engines were made, his engines should be at least described. However we will do better than that. Rough sketches of parts of his engine & a picture-at left may lead experimenters to reproduce this interesting engine. It is quite heavy as COMPRESSED AIR engines go-- 3 ounces. In E.C.J. article John Brown described several variations of this engine. One was a cast iron bodied motor while a bronze body was used on another. A long drill hole in his castings probably caused some wander of small drill. Stock around hole was small & if drill broke through wall Robert would whack off that cylinder & make an experimental two banger or even a one cylinder engine in one case. It had the usual valve porting grooves in the crankshaft.



Cast brass was used for production shafts. Believe it or not, porting is reported to have been stamped into crankshaft on a punch press! Sketch showed a steel shaft which would be more readily fabricated. Cylinder heads & air passage were aluminum & lapped to an airtight (?) fit & fastened with 6-#2-56 screws. #4-36 tap on back of each cylinder was for radial mounting. Though tapped through, short screws would not interfere with pistons. Piston shown on sketch sheet calls for aluminum. This would make a lighter engine. However, if not lubricated, aluminum pistons will gall & stick in aluminum cylinders. Original motor had brass pistons some with cast rod bearings integral with rest of piston. It is suggested that brass rod be used to turn pistons on a lathe, to a lapped fit size with aluminum rod pivots riveted in place.

Several inherent defects exist in this engine besides the weight. A plumber's 1/8" pipe tap was the air inlet connection. This could be OK on a boat but not in a model plane, where weight is most important. Exhausting through slots in cylinder at bottom of piston stroke is not an effective exhaust because piston feels a back pressure on up stroke as air above piston is compressed. There is an exhaust groove in shaft too, according to Brown. Air volume of drilled passage from rotary valve to cylinder head is wasted air on each stroke of each piston. Large diameter of shaft & short length of leakage paths from high pressure to atmosphere makes more leakage than limited air supply can afford. Crank pins threaded into crank throws tend to loosen with vibrations & power forces of running. Murhpy's "Law" says that this would be sure to happen during an important contest flight.

Apparently Hetherington never flew a COMPRESSED AIR model with his engine. No air tanks were made by Hetherington according to Brown & a tank would have been required for flying!

One good thing about Hetherington's engine was that it would start from any position without flipping the propeller or even without any propeller or flywheel if the intake angles are 121° or longer.

Bore & stroke of these engines was 1/2" which would provide considerable power if well fitted & timed reasonably.

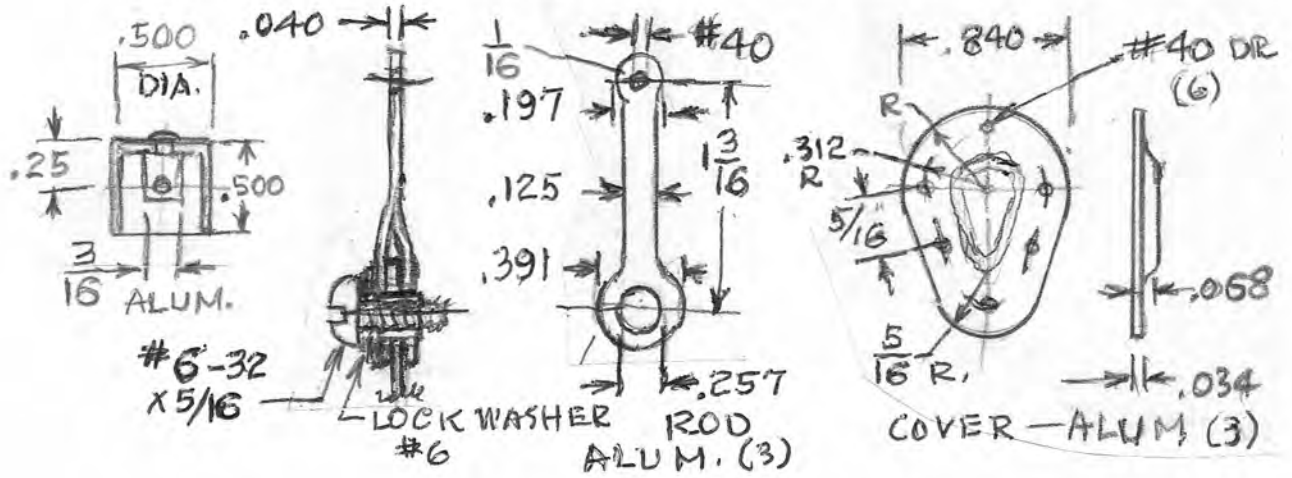
Weight of bronze motor which had a steel shaft & steel cylinder heads was reported to be 6-1/2 ounces. Another even weighed 10 ounces!

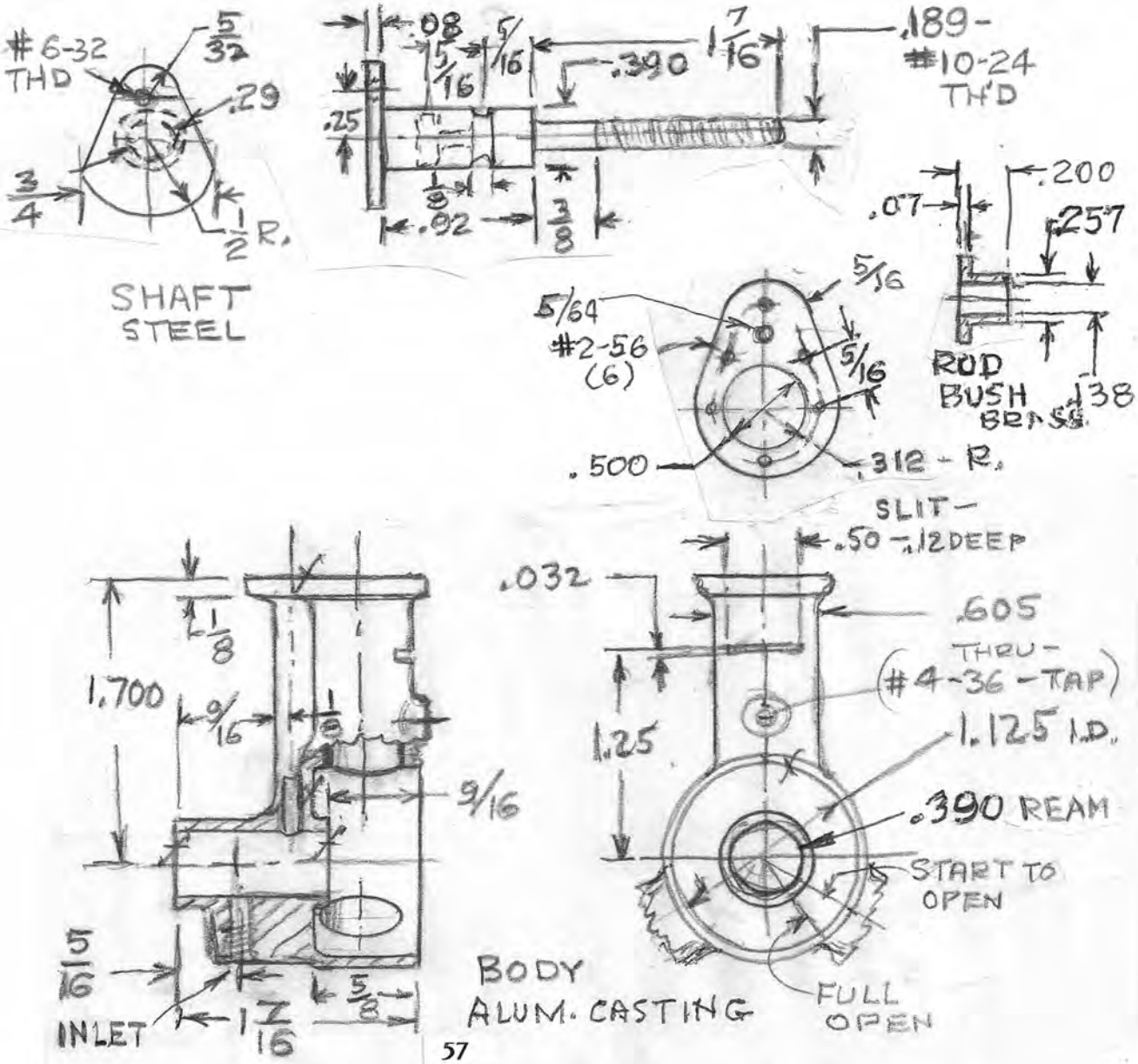
Counterbalance as shown in sketch of crankshaft was used on production engines but not on some of those one-of-a-kind experimental units.

Adopting a cast boat engine made with heavy materials for model aircraft use by merely using aluminum for some of heavier parts is not the best way! Perhaps switching to model gas engines was a wise move!.

Hetherington conducted his work with COMPRESSED AIR engines about 1929 when Whirlwind , Featherweight & other engines were sold.

Rough Sketch of the Hetherington COMPRESSED AIR Engine







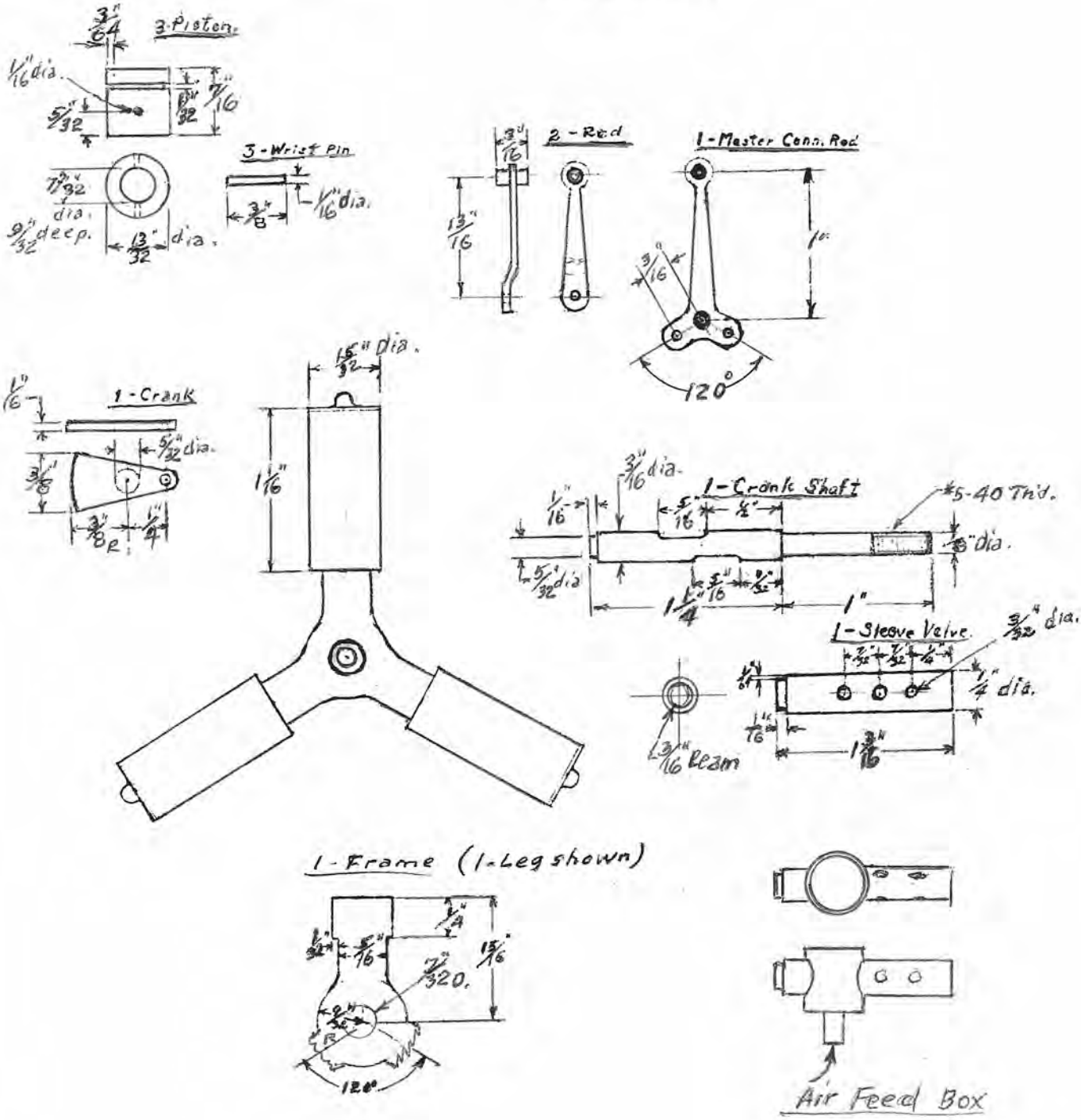
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The Howard McEntee COMPRESSED AIR Model Engine.

Howard McEntee, the well known model builder, flier & author, designed this COMPRESSED AIR engine. Its construction is rather simple & on the order of a 3 cylinder version of the Cavanaugh & the Pachasa twins. The bore & stroke are 13/32" & 1/2" respectively.

The cylinders are made of 1/32" wall brass tube. 1/64" wall tube would work as well & would be lighter.

The pistons are turned from aluminum alloy rod & lap fitted to the cylinders. The pistons are cross drilled for the 1/16" diameter steel wrist pins. Howard used a master connecting rod with 2 auxiliary rods. It would be easier to use 3 rods all alike with 1" spacing between the holes. The angle of the outside connecting rods would be only about 1° to either side.

Howard's drawing does not include all of the details. The cylinder heads are brass washers with a true outside diameter which fits the inside diameter of the cylinder with a very light interference fit. This assures that at least the head end of the cylinder is round! The missing crank pin should fit the rod(s) & be secure in the crank throw. The intake pipes, not shown, are 1/8" outside diameter. They are soldered to the center row of holes on the sleeve valve. The front row of holes is the exhaust. The left row of holes is the intake group. Air is best brought to these 3 holes by means of a single pipe to an air box or plenum as shown in the sketch at the lower right hand corner. Such a box feeds air to the cylinders at a slightly higher pressure for more power.

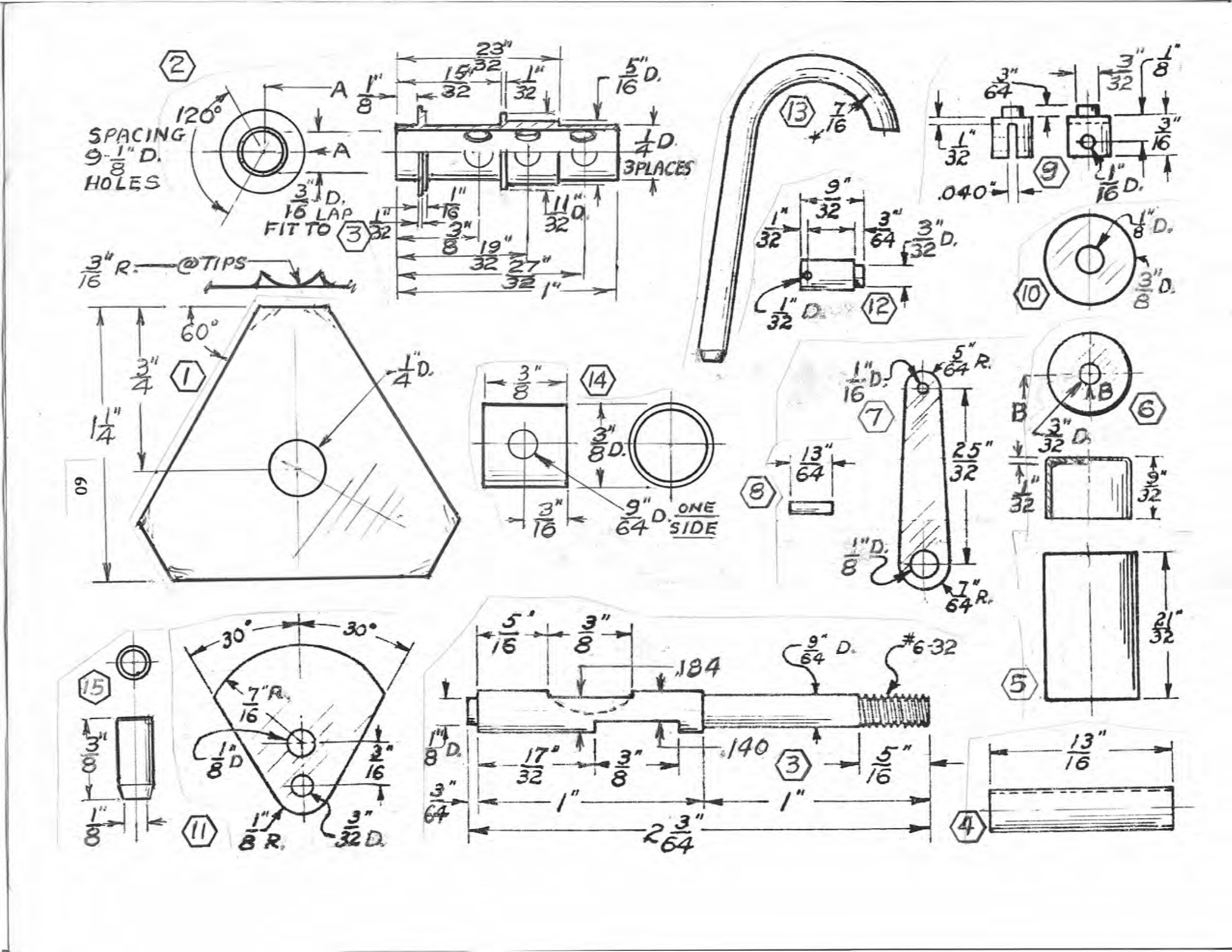
The cylinders should be assembled so that the pistons clear the cylinder heads by no more than the thickness of a piece of heavy paper with the pistons at the top of the stroke. The cylinder should be slid down over the piston until contact is made. Then it should be withdrawn only a few .001" of an inch & soldered. A fixture may be made to assist in aligning the cylinders along a true axial radius at a 120° spacing.

With accurate valve timing & the close lapped fits of the valve sleeve with the shaft & the pistons with the cylinders, this plain engine should be quite powerful. The engine should not weigh more than 1-1/8 ounces or less with 1/64" wall tube cylinders.

If well made, you will have a real good engine!

Bill of Material for Whirlwind COMPRESSED AIR Engine.

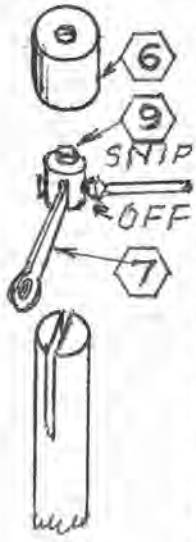
Item	No. Req'd	Name	Material
1	1	Frame	.025" brass or bronze sheet
2	1	Valve-bearing	3/8" diameter brass or bronze rod
3	1	Shaft	3/16" diameter steel rod. Lap to item #2.
4	1	Propeller bushing	3/16" diameter 1/64 wall aluminum tube-K. & S.
5	3	Cylinder	13/32" diameter 1/64" wall brass tube-K. & S.
6	3	Piston	1/2" aluminum alloy rod.
7	3	Connecting rod	1/32" aluminum alloy sheet
8	3	Wrist pin	1/16" diameter brass tube-K. & S.
9	3	Wrist pin boss	3/16" diameter aluminum alloy rod
10	3	Cylinder head	3/8" diameter rod or 1/32" brass sheet
11	1	Crank throw	1/32" hard brass or bronze sheet
12	1	Crank pin	1/8" diameter steel rod
13	3	Air pipe	1/8" diameter 1/64" wall brass tube-K. & S.
14	1	Valve cover	3/8" diameter 1/64" wall brass tube-K. & S.
15	1	Air tube	5/32" diameter 1/64" wall brass tube-K. & S.
16	1	Washer	#6 - brass or steel
17	1	Nut	#6-32 brass or steel
18	-	Wire	.025" diameter brass or steel


2
120°
SPACING
9-1/8" D.
HOLES
A
1/8"
A
3/16" D.
LAP
FIT TO
3
23/32"
15/32"
1/32"
5/16" D.
1/4" D.
3 PLACES
1/16"
11/32" D.
1/32"
3/8"
19/32"
27/32"
1"
3/16" R. @ TIPS
1
60°
3/4"
1 1/4"
1/4" D.
09
14
3/8"
3/8" D.
3/16"
9/64" D.
ONE SIDE
13
7/16"
12
9/32"
1/32"
3/64"
3/32" D.
1/32" D.
9
3/64"
1/32"
.040"
3/32"
1/8"
3/16"
1/16" D.
10
1/8" D.
3/8" D.
7
1/16" D.
5/64" R.
25/32"
1/8" D.
7/64" R.
8
13/64"
6
B
B
3/32" D.
1/32"
9/32"
5
21/32"
15
3/8"
1/8"
11
30°
30°
7/16" R.
1/8" D.
3/16"
1/8" R.
3/32" D.
5/16
3/8
.184
9/64" D.
#6-32
1/8" D.
17/32"
3/8"
.140
3
5/16"
3/64"
1"
1"
2 3/64"
13/16"
4

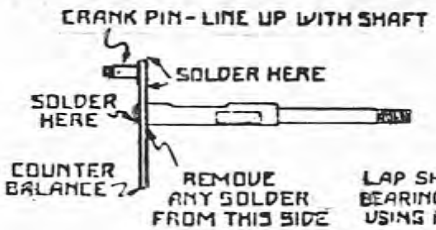
The HOOSIER WHIRLWIND COMPRESSED AIR ENGINE

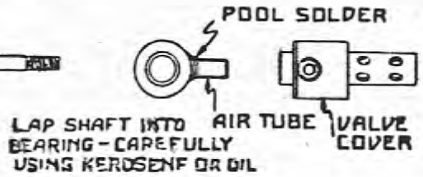
During winter of 1926-1927 I taught a group of high school students in Peru, Indiana how to make & fly model planes. Since there were no corner model airplane supply shops anywhere, material had to be purchased in bulk-tissue by ream, music wire by coils, bales of Tonkin bamboo, balsa from a foreign wood importer, rubber from special fabricator & canoe glue by 5 gallon drum. "Canoe Glue" was later renamed & sold as "Ambroid". Model class used only a modest part of inventory. In hope of getting a little of investment back, a small advertisement was placed in Popular Aviation because it had announced a model plane section. Popular Aviation came out shortly after a Mr. Lindbergh had made his epochal non-stop flight to Paris. Suddenly any & all model aircraft items were in great demand. Literally hundreds of dimes for price lists came in every mail. Being in model aircraft business, whether or not I wanted to be, items were added to lists of available materials including among other items Ott compressed air engines from Amalgamated Sales & Service Company of Chicago, Illinois. These Ott engines were made with somewhat less than required precision for good operation. Since no other suitable engines were available, after researching & experimenting with several types of COMPRESSED AIR engines, one 3 cylinder radial model created such a "whirlwind" that it was so named & put into production in batches of 3,000 engines. This little engine had 3/8" bore & stroke. This Hoosier Whirlwind was soon winning all of compressed air model events. Whirlwinds were powerful for their small size because power of adjacent cylinders overlapped. Valving was such that two cylinders were getting pressure air simultaneously. Rotary shaft valve of small diameter had very small friction torque. With centerless ground shaft lapped to a reamed bearing, air went where it was supposed to go rather than leak excessively. Propeller thrust acted to seal high pressure air similar to rotary seals on refrigerators & water pumps on automobile engines. Pistons were centerless ground to close fit with cylinders. Even a curved slot in valve shaft directed pressure air with a minimum of turbulence from feeder sump to cylinders. These powerful but tiny Whirlwind COMPRESSED AIR motors weigh only 7/8 ounce & have flown lightly built models as large as 8 foot wingspread. If you can file, drill, solder & have access to a small lathe you can make a Whirlwind. A number of people have done so. Drawings have been modified from original parts in some cases in order to make fabrication easier. Performance should not be impaired if care is used in fits of parts & timing of air delivery to cylinders.

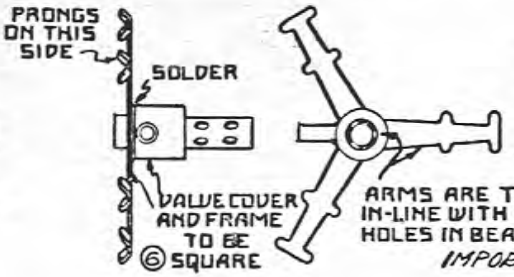
Piston-rod assembly should make a distinct "pop" when pulled from its cylinder. Shaft should fit valve-bearing so that even with light oil a slight drag is felt when moving or rotating shaft. Note that in feeder sump only holes feeding air to curved groove can feed any air overboard forward through lapped fit. Other holes in feeder sump are blocked off & only their small periphery can feed air overboard through lapped fit. This quantity of air is extremely small due to lapped fit and actually it is beneficial. This very small amount of air acts as an air bearing tending to center shaft on an extremely thin cushion of air. Make certain that crank throw face next to valve is in 100% contact with valve for rotary air seal action. Follow drawings, instructions & assembly sheet carefully for best results. Note the simple riveting tool which can assist in assembly. Use a very small ball peen hammer. Avoid striking outer rim edge of piston (6). Peen wrist pin boss (9) until piston (6) can no longer be rotated. Next rivet crank pin (12) to crank throw (11) securely. Then rivet this assembly LOOSELY to shaft (3) so that you may turn it with respect to the shaft. The throw must be positioned a few angular degrees PAST top dead center by observing the intake flat through intake holes in valve/bearing (2). Position may be checked by blowing through air tube (15). After putting pin in correct relation to shaft make certain pin & shaft are parallel & then solder. Any solder which sometimes appears as a fillet on the shaft side of the crankthrow should be carefully removed. You should solder the crank pin (12) to the crank throw at the same time that the shaft is soldered to the throw assembly. Use a small hot iron & remove quickly as soon as the joint is soldered so that other joints will not become "unsoldered". 97% tin & 3% silver solder is recommended because of its strength & ease of use. Remove flux with hot water. Run in with light oil. Attach to the biggest possible tank model can carry & you are a COMPRESSED AIR modeler!

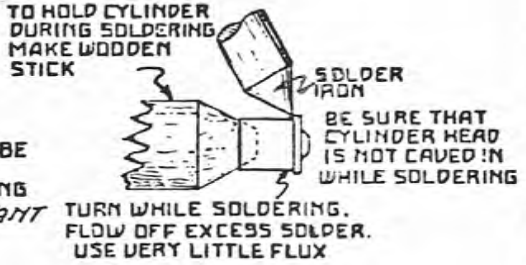


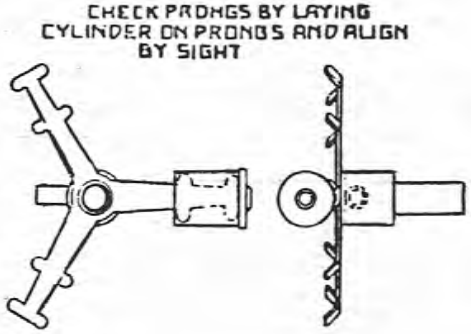
INSTRUCTIONS FOR ASSEMBLING THE HOOSIER WHIRLWIND COMPRESSED AIR MOTOR. PERFORM OPERATIONS IN ORDER AS INDICATED.

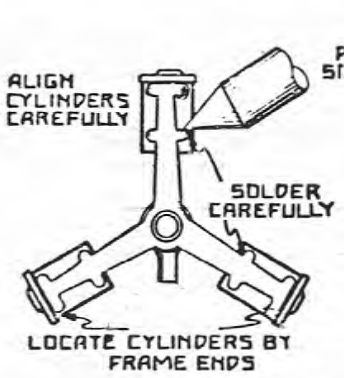


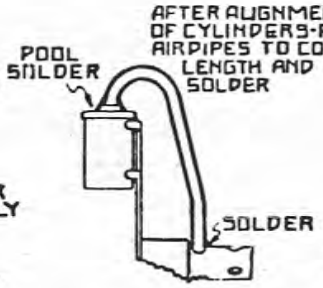


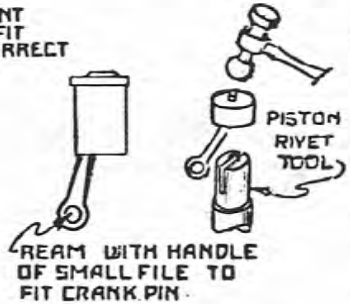


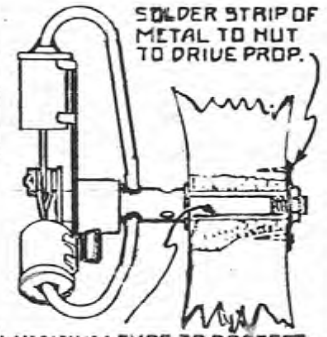


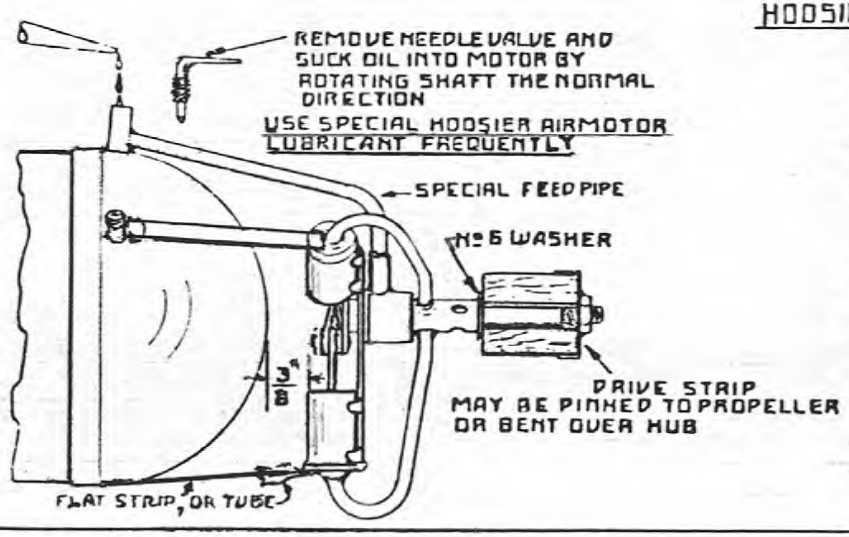












HOOSIER WHIRLWIND COMPRESSED AIR MOTOR

USED BY NATIONAL CHAMPIONS —
SOLD ALL OVER THE WORLD —
USED EITHER ON MODEL AIRPLANES OR BOATS —
MAKES LIGHTEST, SAFEST AND MOST EFFICIENT POWER PLANT WHEN USED WITH HOOSIER AIR TANK

POWERFUL - HAS FLOWN 8-FOOT WING SPREAD SCALE MODELS
- 3/8" BORE, 3/8" STROKE
- IMPROVED VALVING

LIGHT - WEIGHS LESS THAN 7/8 OUNCE
- MANY DURAL PARTS

STRONG WHERE NEEDED —
- STEEL CRANKSHAFT

ACCESSIBLE - LUBRICATION VERY SIMPLE
- EASILY REPAIRED
PISTONS MAY BE REPLACED WITHOUT REMOVING MOTOR FROM TANK

SMOOTH RUNNING: COUNTER BALANCED

IDEAL FOR 2 OR 3 MOTOR JOBS - EASILY MOUNTED ON TANK OR ON WINGS.

FINAL OPERATIONS:

A KEEP PISTONS AND CYLINDERS PAIRED
B OIL PISTONS
C SLIP INTO CYLINDERS
D SLIP RODS OVER CRANKPIN
E BEND OFFSETS IN TWO OUTSIDE RODS SO PARTS ROTATE WITHOUT BINDING.
F SLIP FIBER WASHER IN PLACE
G SCREW NUT TIGHTLY ONTO CRANKPIN - OR "COTTERPIN"
H OIL MOTOR WELL AND RUN-IN WITH POWER OR BY AIR

Bert Pond, 1929

62

COMPRESSED AIR Walking Beam Engine.

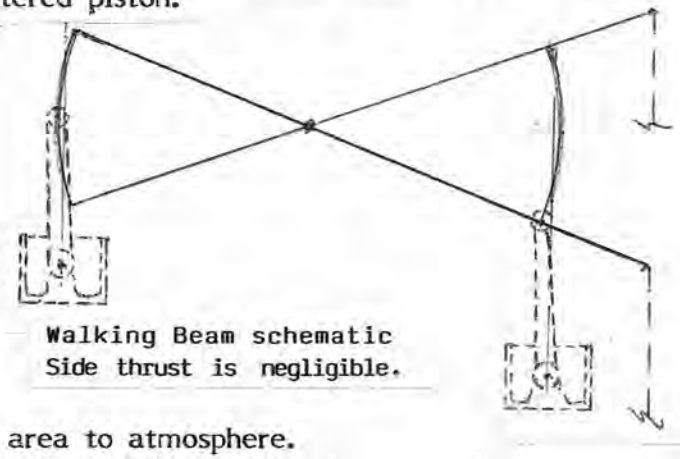
A walking beam engine? Other than an oil well pump jack most people would expect to have found a walking beam engine in a colliery or a water works pumping station in the 1800s.

Because of a desire to develop an improved COMPRESSED AIR engine with a high efficiency to be used with those light weight plastic tanks developed by Mr. Humphries in England, a list of desireable features which such an engine should have was compiled. Numerous engines were examined. From this list, a Walking Beam design has more features most wanted than any other engine configuration.

1. No tube between valve & cylinder.
   No tube needed in walking beam arrangement. Cylinders are mounted so that valve window openings coincide with openings in cylinder head. Air volume in a tube would be wasted each revolution.
2. No power required to operate valve.
   Use of shaft as valve requires no additional energy. Disc, cone, poppet, slide, oscillating & most other types of valves take energy away from engine output.
3. No side thrust of piston against cylinder wall.
   Walking beam geometry maintains piston thrust substantially axial with cylinder. 100% of force from piston is transferred to walking beam. In engines with piston & connecting rod connected directly to crank, piston side force which rubs cylinder wall is a hefty 20% to 35% of total axial piston force. This large side force tends to wear piston more rapidly. Piston against wall of cylinder leaks twice the quantity of air as a centered piston!

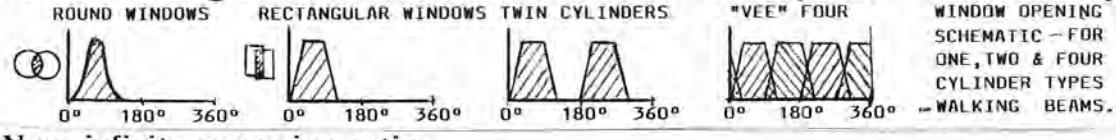


Forces on a conventional connecting rod. Note large side thrust force.



Walking Beam schematic
Side thrust is negligible.

4. No short film paths from pressure area to atmosphere.
   Walking beam shaft has long film paths. Disc & cone & many other types of valves have narrow lips & short film paths to atmosphere.
5. No piston drag.
   Lapped walking beam pistons have no drag to absorb power. Piston rings & cup washers on top of pistons press against cylinder walls & reduce power output of engine.
6. No slow air valving.
   Rectangular valve windows in walking beam engine allow quick intake & sharp cutoff for greater expansion & efficiency. In some engines, round windows open & close with gradual intake & slow cutoff for less expansion & decreased power.



7. Near infinite expansion ratio.
   Walking beam pistons are readily set at assembly to smallest head space. This provides maximum expansion ratio for high efficiency.
8. No pressure drop from tank to engine.
   Two small plenums-one internal & one external- smooth air flow to cylinder with air "at the ready" when valve opens. Without these reservoirs, valve would open on pipe to tank with possible pressure drop & loss of power.

A Super-efficient Expansion Engine-Walking Beam Type.

1. It is efficient because it has no pipes between valve & cylinder.
2. It is efficient because the connecting rods operate practically on the center lines of the cylinders without the usual side thrust & friction with energy loss.
3. It is efficient because all shafts are long for minimum wear & small in diameter to maintain friction torque losses very small.
4. It is efficient because the gas, air or vapor is introduced more quickly by way of square or rectangular windows than it would be through round windows. This builds up pressure at an earlier angle for greater expansion angle & energy recovery.
5. It is efficient because there is only one small tolerance at each joint which saves so called lost motions.
6. It is efficient because a reservoir of medium at full pressure is at the valve waiting for the valve to open allowing for a more smooth flow from the tank.
7. It is efficient because there is no wasted volume of the medium between the piston & the cylinder head due to method of assembly.
8. It is efficient because there are no cup washers on the piston to cause power robbing friction.
9. It is efficient because of the length of the close fitting shaft & valve pressure reservoir to atmosphere conserves leakage to a low minimum.

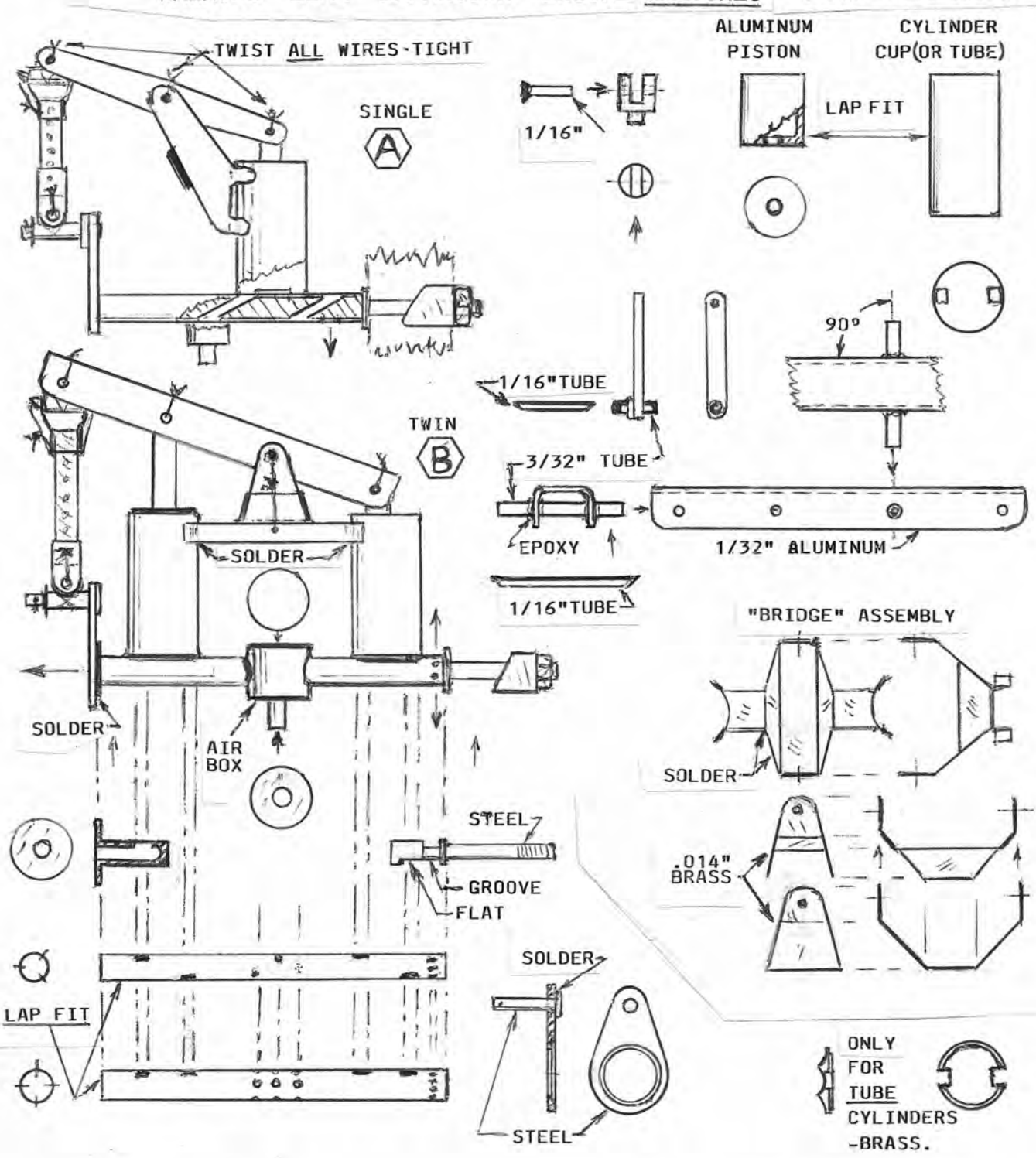
All of the above & more adds up to much greater flight duration in model aircraft. The engines are light in weight. All which have been made weigh less than one ounce, except the most recent 90° Vee 4 which weighs 1.2 oz. (34 gm.)

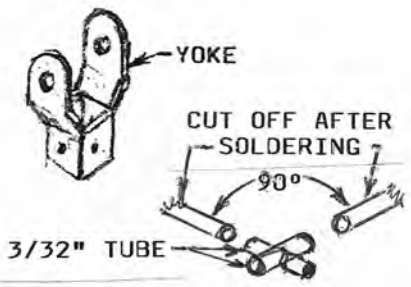
The ⟨A⟩ type is the more easily constructed than the ⟨B⟩ twin configuration. The ⟨A⟩ type has made flights of one minute duration. The ⟨B⟩ type has not been fully tested in flight yet because it is too new. However the twins which have been tested all perform exceptionally well, well enough that these sketches are being included in this book. Formal drawings have not been made because the engines have been made without the need for drawings. The sketches however are quite close to scale. Slight changes in the bore & stroke make large changes in the power output which will fly models of 40" to 70" span.

Making the engines is a bit tedious. Small needle files & magnifying eyeglasses help to make the work easier. As usual, close lapped fits of the air handling parts are essential. The other most important items are the window angles. Use of tool makers layout fluid with a sharp needle to scribe the lines makes the areas to be removed more visible. The intake total angle should start at about 5° & cut-off at about 90° to allow angle travel for expansion. The exhaust should open about 175° & close near 345°. The second cylinder window angles are simply 180° in addition to the other window angles. Measuring the angles of such small windows may seem difficult but it becomes easy if you have a protractor & a short snap line level & a narrow piece of .001" to .003" shim stock. Pinch the shim gently in both directions with the level attached to the valve sleeve & the protractor attached to the shaft. Readings are taken with the protractor while the bubble in the level is centered. The difference in the two readings of course is the angular width of the window opening. The same method will measure the angle between 2 different windows. The thickness of the shim makes a small error of 1/2° to 2° & is not a big factor.

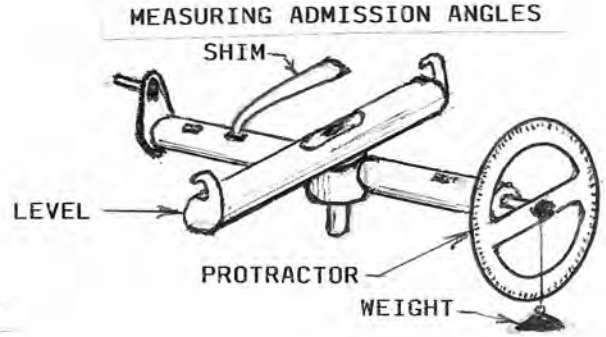
The ends of the walking beam connecting rod move in planes that are at right angles to each other. This requires that universal joints be used. The crosses or knuckles are made by soldering tubes together at 90° as sketched. The yokes are made from square telescopic brass tube cut away on 2 sides & drilled & spread on the remaining sides. One end yoke is soldered fast to the smaller square connecting tube. Note that the ends of all tubular shafts are filed to a 45° angle with 90° between the 2 ends. When finally lock wired tight, this angle not only prevents movement in the bearings but also prevents rotation. In order to make the pistons barely miss the cylinder heads, first assemble the engine with a disc of paper in a cylinder. Push the piston tight against the paper disc. Then with the crank throw in its dead center position, slip the square connector rod in position with the one end only soldered & solder the loose end. Rotate the shaft 180° to make sure that the other piston is clearing OK too. Remove the paper disc. Oil & reassemble the engine. Be sure to lock wire all joints. Attach a propeller & you have a power plant that will surely shake up the "natives".

WALKING BEAM EXPANSION ENGINE-SKETCHES (ABOUT FULL SIZE).



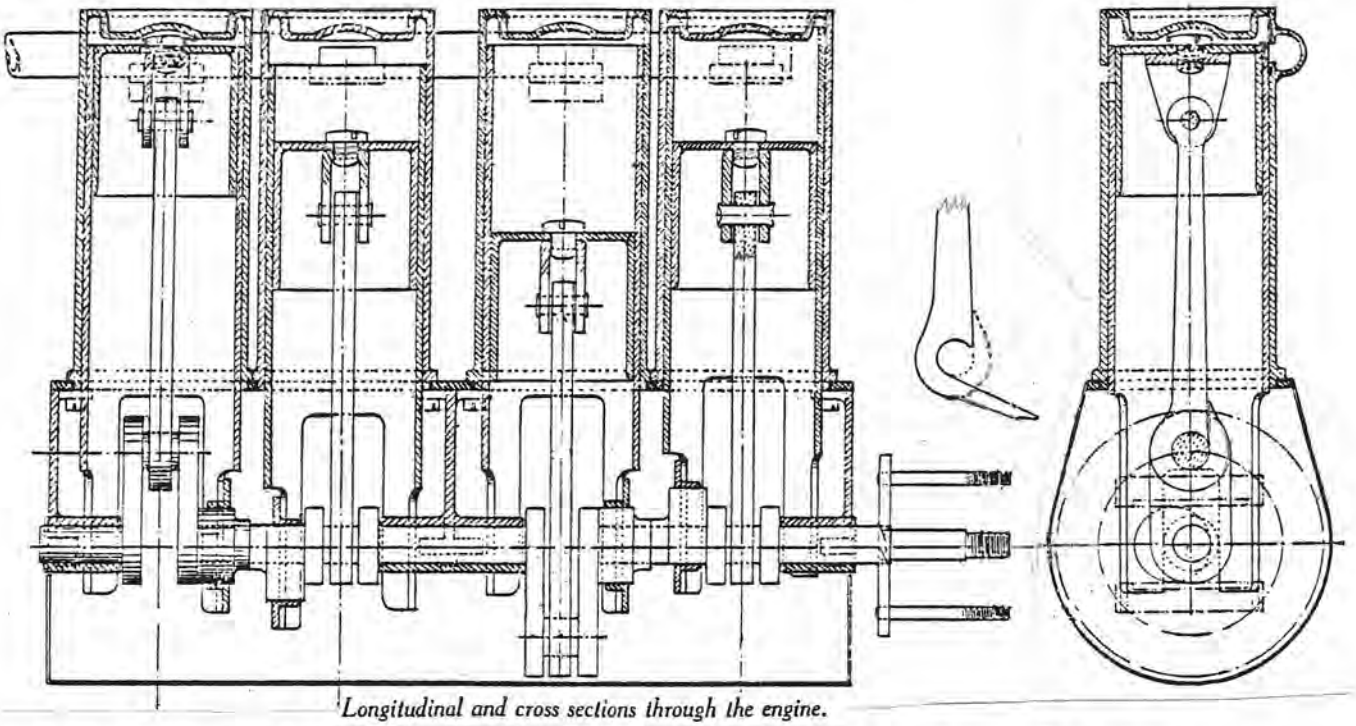


UNIVERSAL JOINT CROSS



A Willys Knight Sleeve Valve 4 Cylinder COMPRESSED AIR Engine.

Sorry! Most people have never heard of those old automobiles with sleeve valve engines. There were several makes of cars which were equipped with this type of engine. The sleeves were operated at half engine speed since they were 4 cycle machines. This little COMPRESSED AIR engine is 2 cycle so the sleeves are operated at crankshaft r.p.m.
Drawings for this unusual engine appeared in the March 1934 issue of Practical Mechanics magazine in England. Three scales were given so that the builder could choose the piston size from 1/2", 5/8" or 3/4" diameter. The 3/4" size of piston is shown in side & end views.



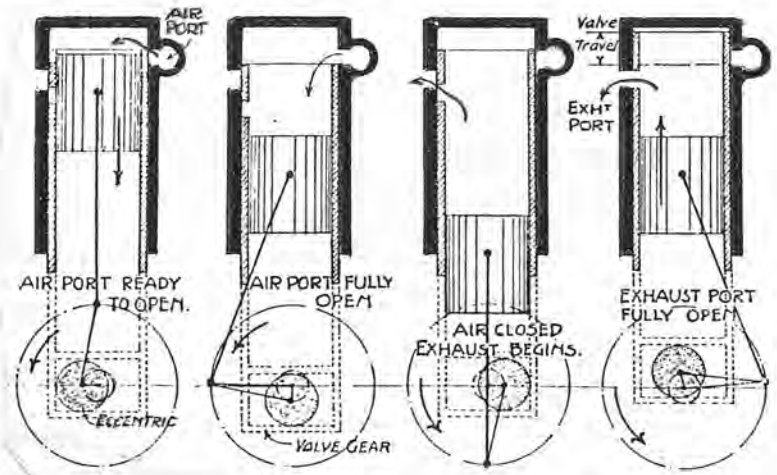
Longitudinal and cross sections through the engine.

Note in the view above that the engine has 3 crankshaft bearings. Two short bearings are on the ends & a long one is in the center. The bearings are split. The caps are removable just like automotive type engines. They are held in place with 2 screws. The 3 bearings must be accurately aligned so that the shaft will not bind. Close fitting vertical slots in the sleeve valves guide on the outside diameter of the bearings. These slots prevent the valve from rotating but allow it to move vertically. The vertical movement is produced by eccentrics between cylinders #1 & #2 & also between #3 & #4. These eccentrics operate in a horizontal space closely fitting the diameter of the eccentrics. This space is formed by 2 small angle pieces. The upper piece is soldered in place initially in all of the sleeves. The lower angle piece is carefully fitted ready to be soldered in place at the correct sequence in assembly. Otherwise the crankshaft could not be fitted into place. Note also the slots in the sleeve for clearance with the crank throws & connecting rods. Allow at least 1/32" clearance on each side.
IMPORTANT: The angle of the eccentrics from the crankshaft centerline to the largest radius should be 90° to 95° AHEAD of each crank throws position in respect to the direction of rotation.. According to the designer, this will provide good valve sleeve timing. Crank cheeks are best clamped together for drilling so that the hole spacings will be identical. Locate all of the crankshaft parts accurately both lengthwise & angularly & hard solder all joints. Clean off flux & polish bearing surfaces with rouge or crocus cloth strips. Then the portion of the shaft between the cheeks should be removed carefully without bending the assembly.
The slots in the cylinders & valve sleeves must be located so as to allow the proper feeding & discharge of air. See the Cycle of Operations diagram.

When properly fitted, this engine should be very economical in the consumption of air. The valving is placed at the point where the air is used so that air is not wasted here. Another way to save air is to make sure that the pistons come as close as possible to the cylinder heads at the top of the stroke without touching.

The plate to which the cylinders are inserted & soldered is flat & narrow so that it could flex. Also the designer did not show a mounting means for the engine. So in order to strengthen this backbone of the engine & provide a mounting means, it is suggested that channel like flanges be added to each side. See the Butterworth engine.

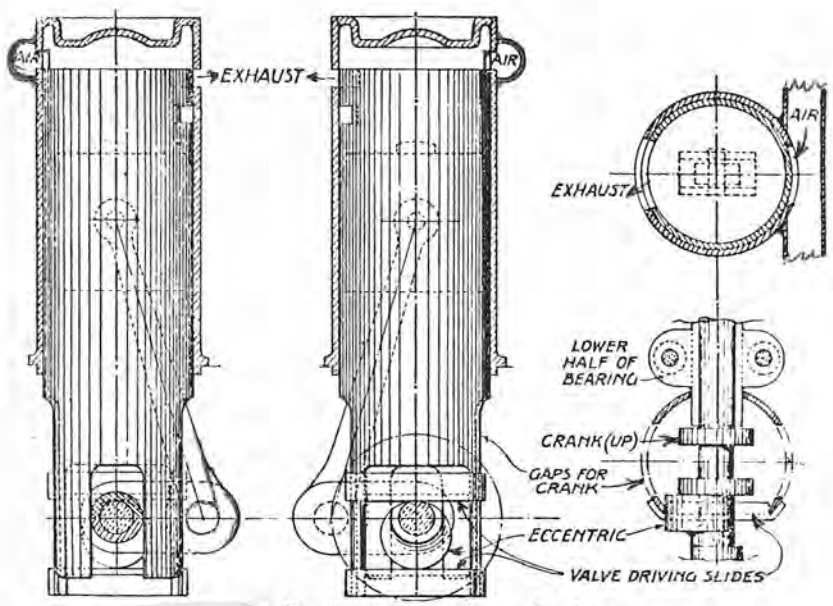
A 1/4" diameter air pipe is carefully filed to fit the radius of the cylinders so that the air inlet windows are covered. With a small reservoir with an air tight removable cap for oiling, & an on-off valve installed in the pipe the assembly should be soldered in place. The other end of the pipe is soldered shut. The exhaust slots in the sleeve valves must all face in the same direction. However the vertical guiding slots at the bottom of the #1 & #3 sleeves are opposite from these slots in the #2 & #4 sleeves.



The cycle of operations in the engine.

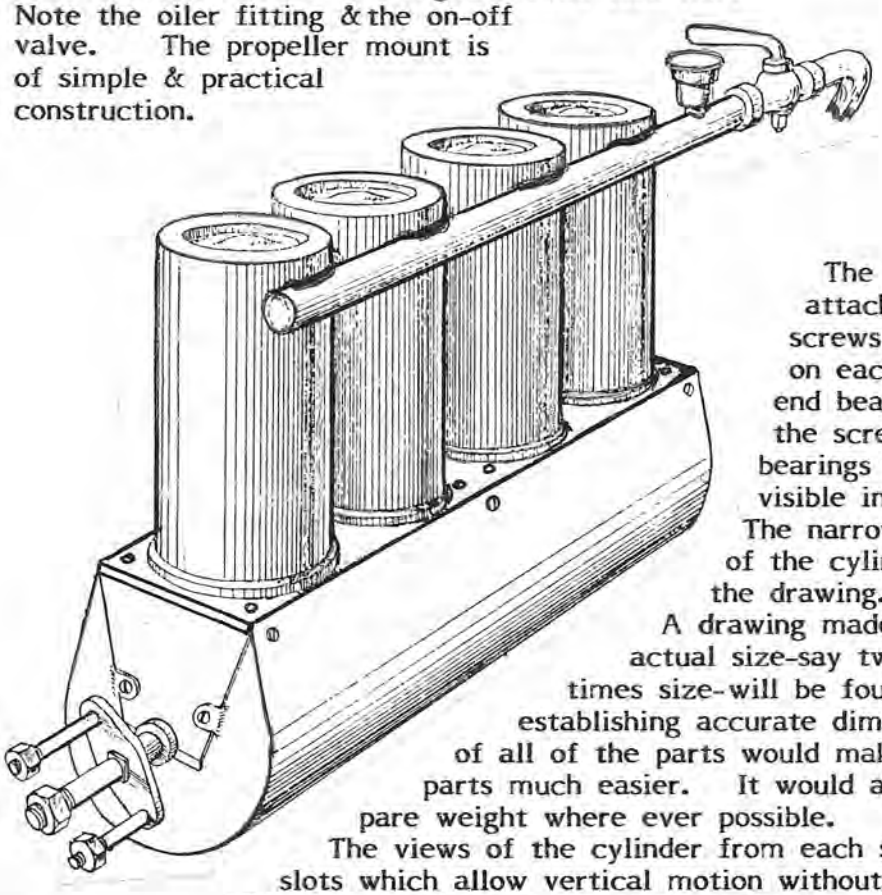
The designer noted that the bottom ends of the connecting rods were too narrow for two screws to retain a conventional bearing cap. Since all of the operating forces are acting in a direction which keeps the rods in contact with the crank pin, he decided to keep the rods in place by bending a tang as shown around the pin. It is suggested that test pieces be tried in order to get the right proportions. When a suitable shape is found all of the rods can be made to this pattern. Select a soft material, such as brass, with little or no spring back when being bent. Bending these tangs would be about the last assembly operation.

The bearings appear to be like castings. However they can be fabricated from tube & sheet pieces hard soldered together with care. These bearings can be made quite light in weight. The curved wrap around bottom enclosure is non-functional so it may be omitted to save weight. Further the oiling of the bearings would be much easier to do with the pan omitted.



Details of sleeve valve and valve gear

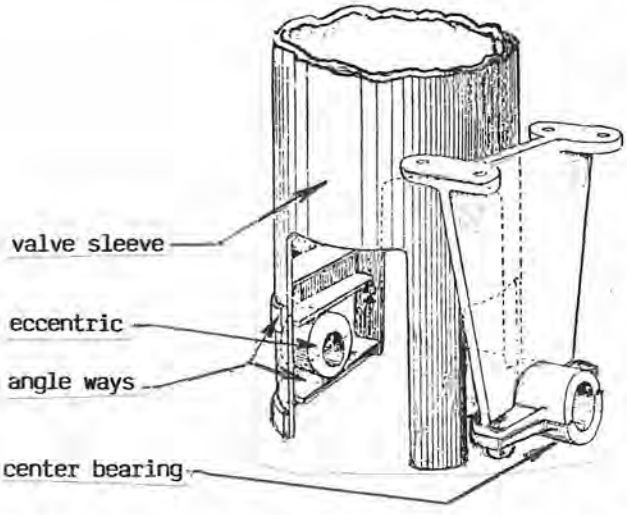
Here is what the finished engine should look like. Note the oiler fitting & the on-off valve. The propeller mount is of simple & practical construction.



The crankcase pan is shown attached with three small screws on each side & two on each end tapped into the end bearing. The bottoms of the screws which hold the bearings to the base plate are visible in the drawing on the left. The narrow flange around the base of the cylinders is also visible in the drawing.

A drawing made to a larger scale than actual size-say two times or even five times size-will be found very helpful in establishing accurate dimensions. Detail drawings of all of the parts would make the fabrication of parts much easier. It would also enable the builder to pare weight where ever possible.

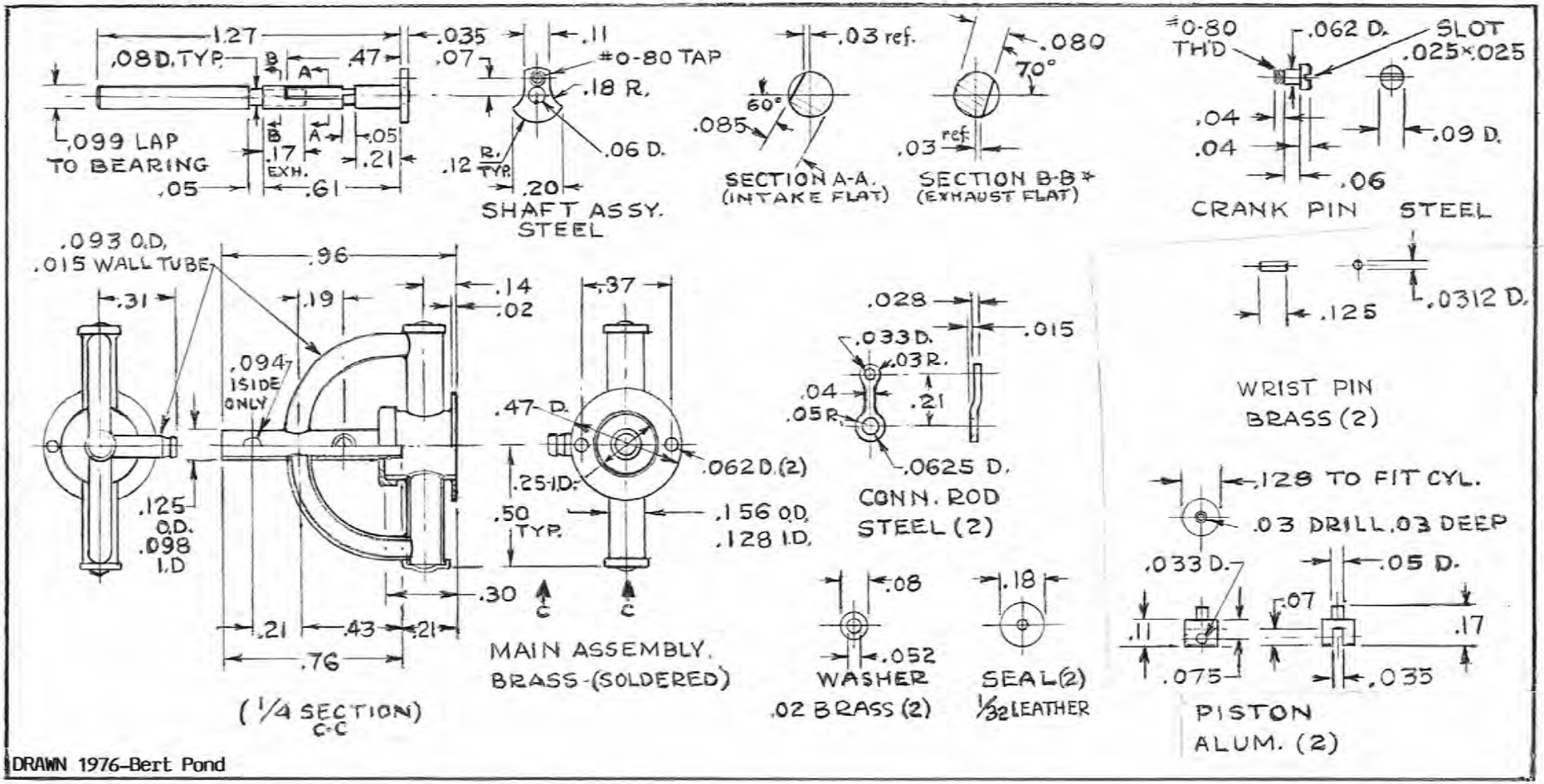
The views of the cylinder from each side show the guide slots which allow vertical motion without rotation on the left hand. The right hand shows the small angle pieces which form the horizontal surfaces contacted by the eccentrics in moving the valve sleeves vertically. The bottom angle pieces are the very last thing to be soldered in place having been previously fitted accurately to a space as wide as the diameter of the eccentrics.



The sketch on the left shows the bottom end of the valve sleeve with the center bearing in position. An eccentric is shown in the aperture in which it operates but without the crankshaft to which it is normally attached. Care must be taken to avoid distorting the thin walled sleeve in the notched bottom areas.

You will note that the piston assemblies will have to be assembled with the sleeves by inserting them from the top side. Then the sleeves with the pistons inside can be inserted into the cylinders.

Next the bearings attached to a straight rod for alignment are attached to the base plate. Then the bearing caps are removed along with the rod. Now the crankshaft assembly is dropped into place & the bearing caps attached. Then only the bottom horizontal guide angles need to be soldered & the connecting rod tangs bent around the crankshaft. The engine should be able to be turned by hand perhaps with the help of a little oil. After a short period of turning by means of a lathe or drill press, air could be connected. The engine is self starting & will have considerable power in proportion to the pressure. It should be anchored well when run with air pressure for this reason.



DRAWN 1976–Bert Pond

This tiny engine was an experimental model built by the late Jimmy Walker. This little gem has considerable torque. Drawing is exactly as Walker made motor. Walker's idea was to have a control line model using a small air hose as one of the lines. In this way a model could be flown as long as air supply lasted. Motor is only 1.40" X 1.00" X .5" & makes a fine project for people having a small lathe & a lot of patience! The exhaust is an outboard hole on the bearing, & intake pipe is at inboard location. You may wish to modify design so that pistons do not overlap feed pipes. Bearing- crankcase could be made in one piece from 1/2" brass rod for ease of assembly. Crankcase would only need to be .21" deep. Original motor weighed a mere .14 ounce! Scale of drawing is non-standard due to photo-reduction. The displacement of this 1958 motor is .0036 cubic inches. Shape leather seal by wetting first & then pulling it into piece of cylinder material & allow to dry. Then oil.

PATENTS ON PRESSURE OPERATED ENGINES

A large number of patents have been granted on engines operated by pressure. The principle of operation is generally similar whether the media is gas, air, steam or even liquids. Other than with turbine types which operate normally with a fixed valve, some type of intermittent operating valve is required to admit the medium under pressure at the appropriate time to move the piston & start a rotary motion. Liquid & steam driven engines are normally heavier than than expansion engines as used in model aircraft.
On the following pages are shown a few model airplane model & engine patents plus one to show a novel reversing valve.

FOX PATENT. Page 71 shows the turbine type with several stages of expansion. Operation of the valves & the weight of the assembly would appear to render the turbine powered models performance marginal.

517881 PATENT. Page 72 is a copy of a German COMPRESSED AIR model plane & engine & box patent. This is a nut & bolt assembly type of model.

HOLTZMAN PATENT. This is a rotary type engine. The entire engine revolves on the stationary crankshaft. These engines were known as the Bates "Gyroette." They were made in either 3 or 6 cylinder configurations. Cylinders were either brass or aluminum. The crankcase, cylinder heads, pistons, mounting bracket & crankcase cover were also aluminum. Fig,5 on the drawing shows the conventional cup washer used to seal the piston against air leakage. It is held in place with a washer & screw. Stroke is 7/8" & bore is 9/16" nominally. Aluminum cylinders had a slightly different bore. Shaft, crank throw & pin are steel. Another almost identical engine to this onediffered mainly in the air pipes which admitted the air to the top centerline of the cylinder head rather than on the side as in the Holtzman engine. These engines, even the 3 cylinder models were very powerful & used so much air that they were not too practical.

POND PATENT. Page 74 is a 3 cylinder radial engine with a rotary valve crankshaft & an air plemun over the valve area. This is the "Whirlwind" engine. This 7/8 ounce weight of engine packs a great amount of power because the valving allowed two of the cylinders to be working at one time. Other engines in 1928-1929 were either too heavy, too powerful for any practical use, blew out pistons by buckling the rods so the Whirwind was designed to overcome these problems. The Whirlwind will be discussed more completely elsewhere.

FENTON PATENT. Page 75 shows a reversible valve mechanism. A slotted rotor can be positioned either side of top dead center position of the pistons to result in either direction of rotation as desired. The connection of the rods to the crank pin is an interesting method called slipper rods. This allows the center lines of the rods to be in the same plane.

There are a great number of engine patents. A book could be filled with them! There are oscillating cylinder engines, oscillating valve engines, engines with vanes in place of pistons similar to the Wankel engine. The description & claims of the patents above have been omitted because they are lengthy & expressed in a technical jargon typical of patents. As customary in patent applications, 20 claims are usually submitted. (Over 20 cost more) The Patent Office rejects claims which are not allowable for various reasons. Then these rejected claims may be replaced with other claims up to the total of 20 for no additional charge. All over 20 claims allowed cost extra.

Regarding the Whirlwind patent, insufficient claims were allowed to make pursuing the matter to granting uneconomical especially during the depression.
All of the patents above have now expired so anyone has the legal right to make use of any of them.

Apr. 3, 1923. 1,450,282

E. F. FOX

TOY

Filed Apr. 4, 1922 2 sheets-sheet 2

Fig. 5.

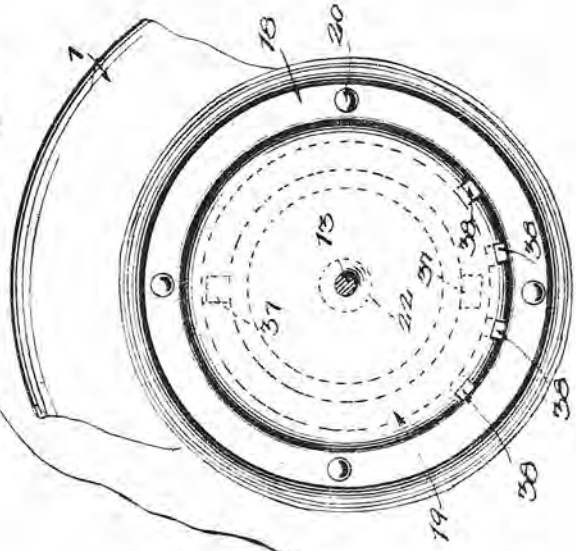
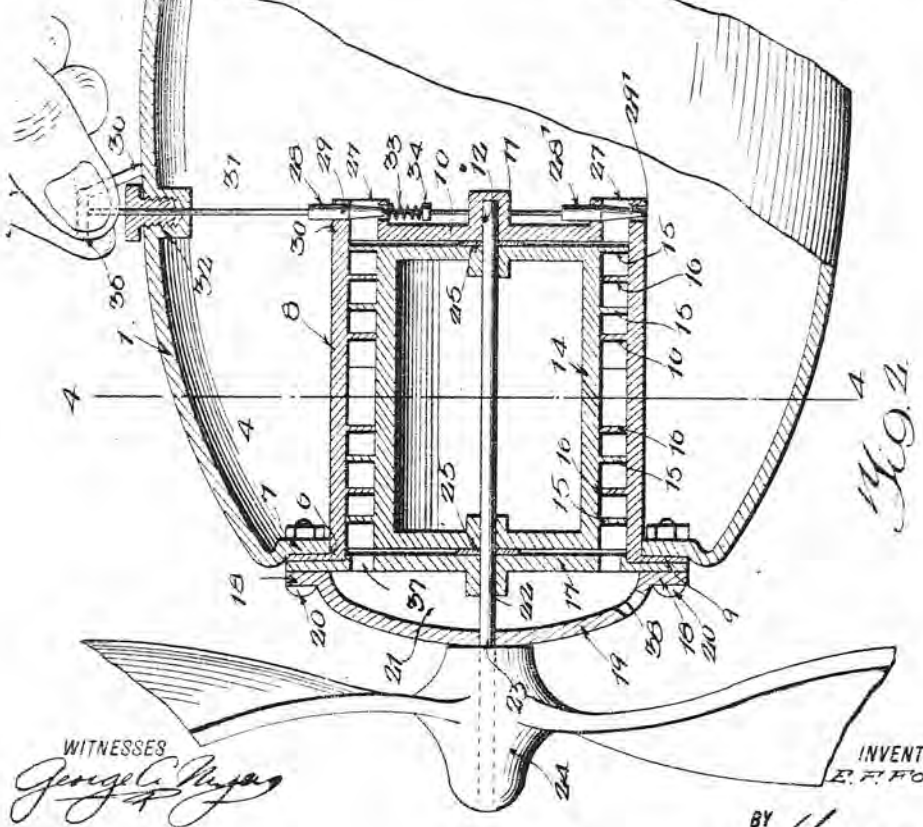


Fig. 4.



WITNESSES

George G. Myers

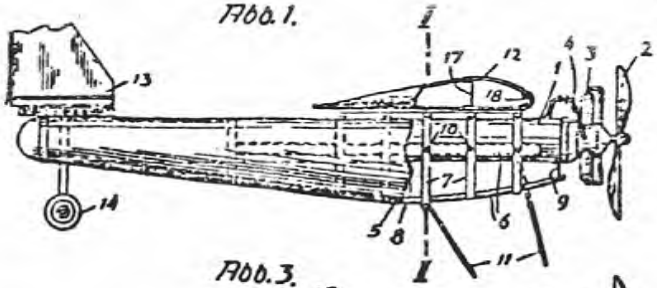
INVENTOR

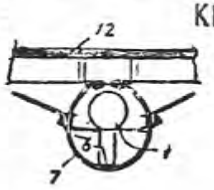
E. F. FOX,

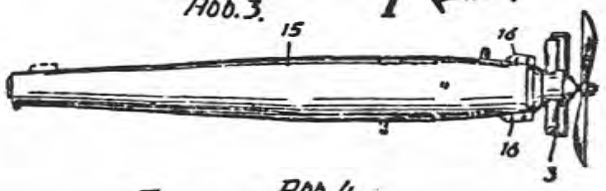
BY Munn & Co.

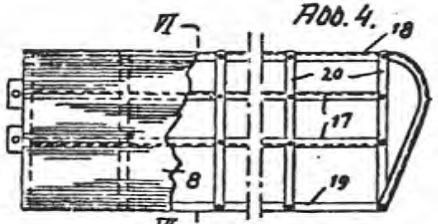
ATTORNEYS

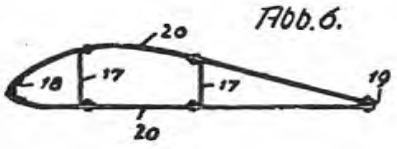
Zu der Patentschrift 517881
Kl. 77f Gr. 28

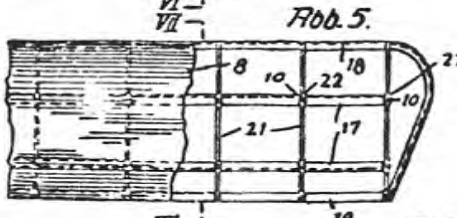


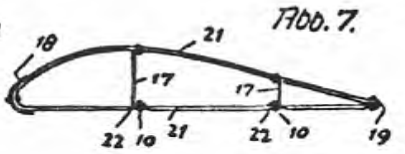


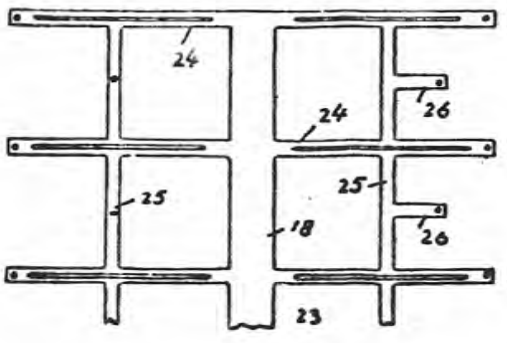


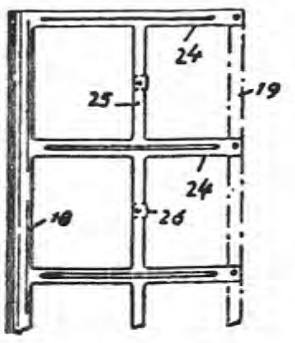


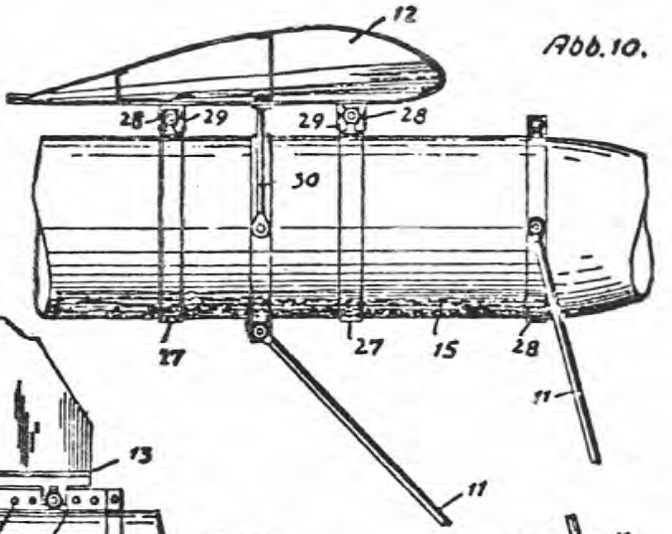


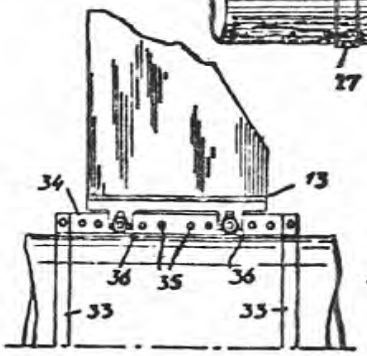


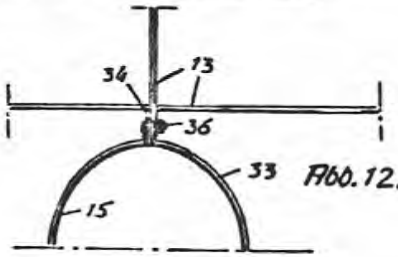


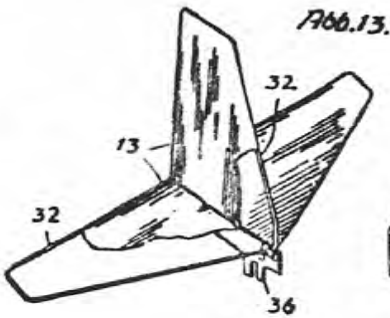


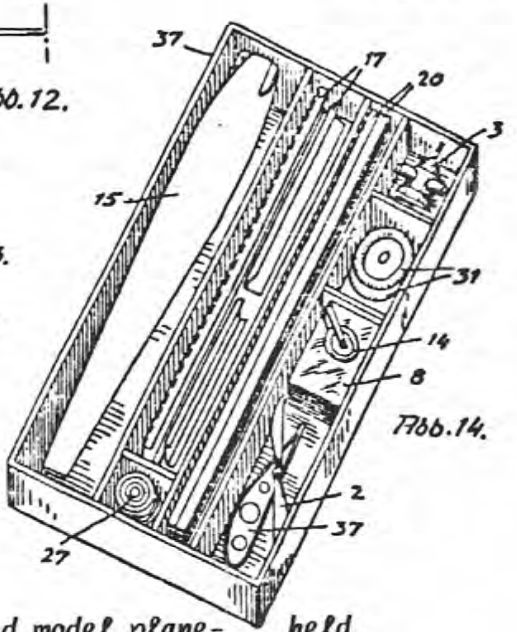












German Compressed Air Model Airplane Patent. This is apparently a metal framed model plane- held together with small bolts & band clamps. (Courtesy of Mr. G. Everwyn)

Fig 1

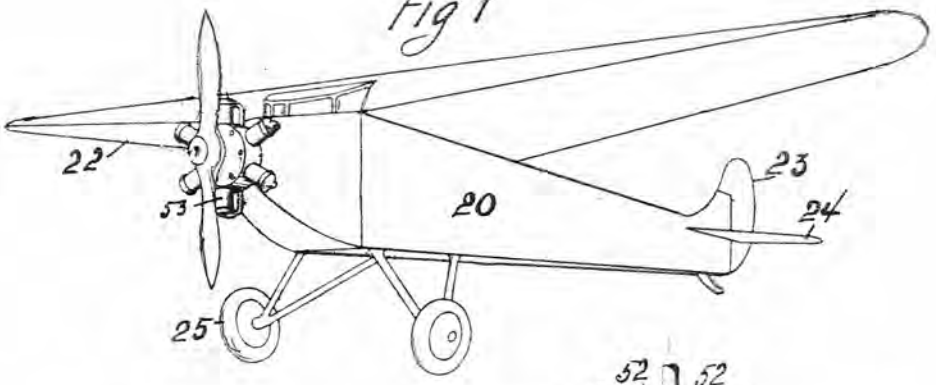


Fig 4

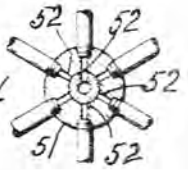


Fig 2

Fig 3

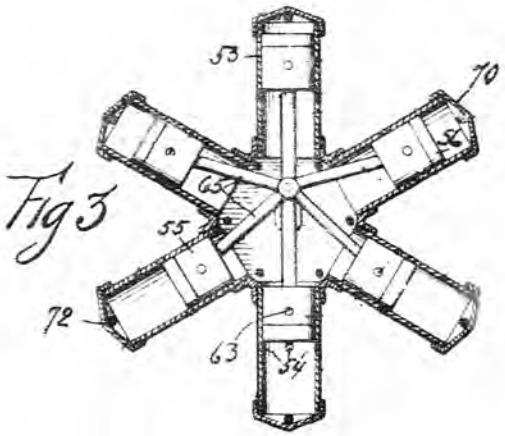
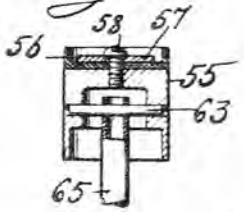


Fig 5



INVENTOR
John Holtzman
BY A. A. deBonneville
ATTORNEY

462376
DIV 62

CLASS..... SUB. CLASS

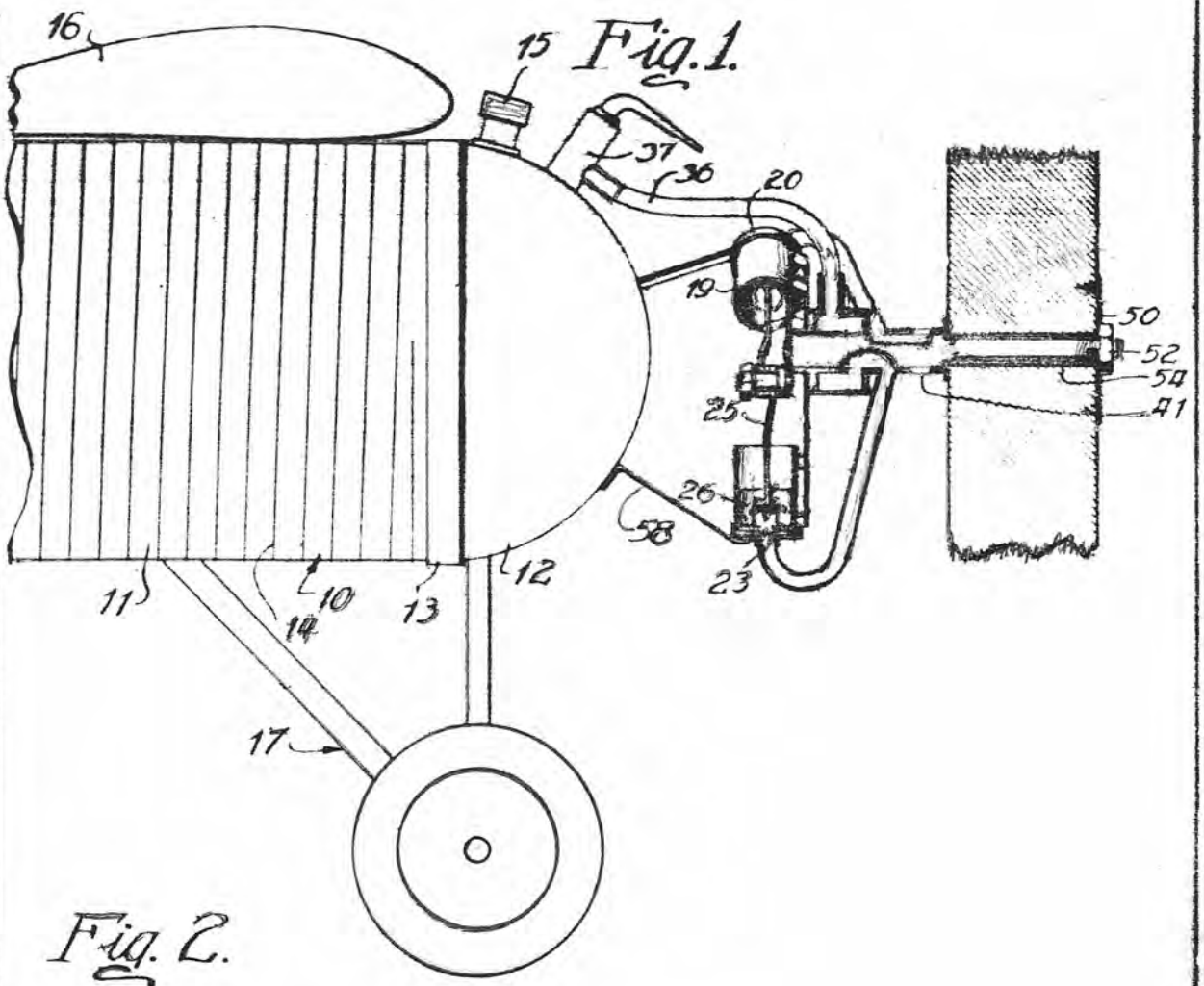
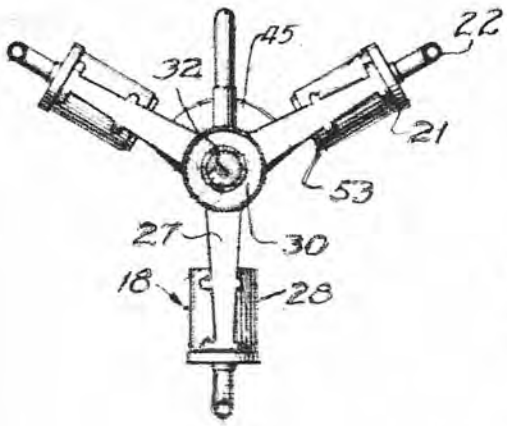


Fig. 1.

Fig. 2.



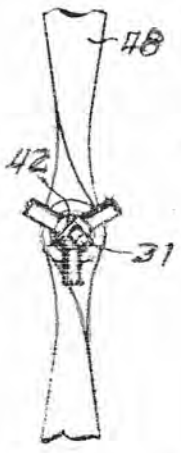


Fig. 3.

INVENTOR
Bertram P Pond

NO MODEL.

No. 727,772. PATENTED MAY 12, 1903

J. T. FENTON.

VALVE MECHANISM.

APPLICATION FILED APR. 10, 1902.

2 SHEETS—SHEET 2.

Fig 1

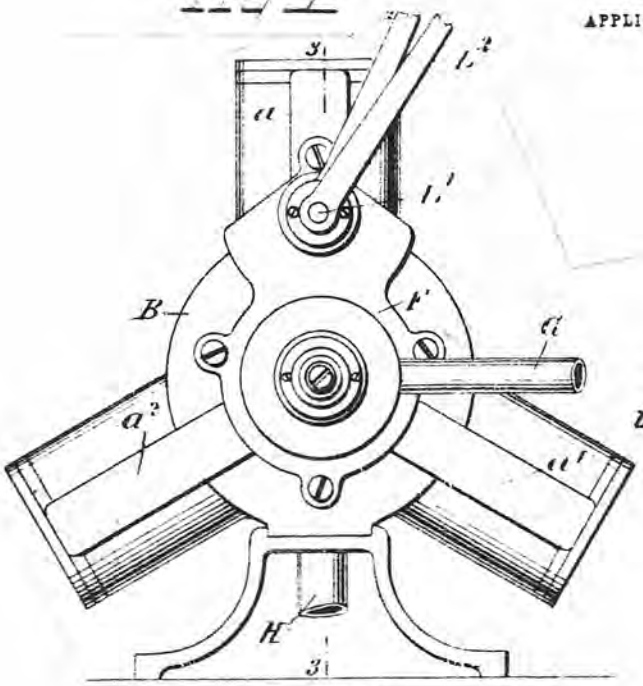


Fig 3

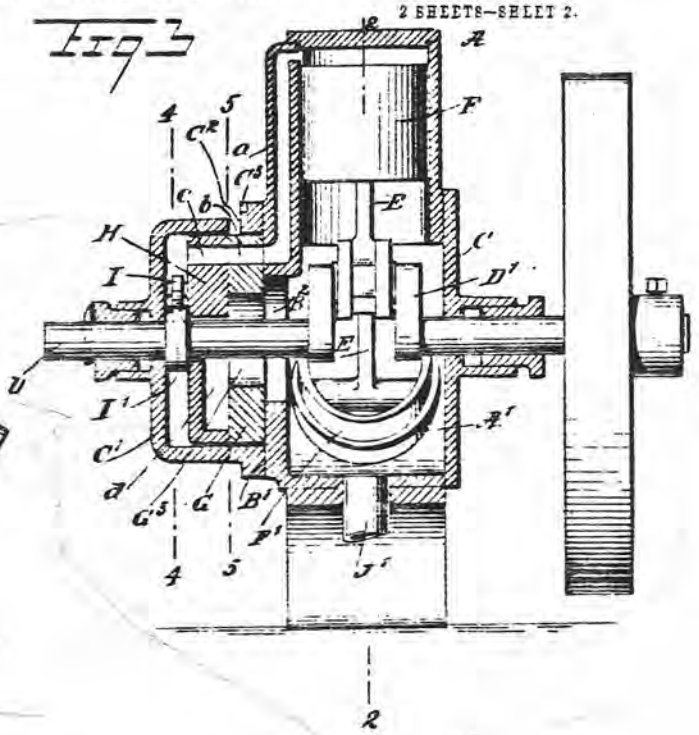


Fig 2

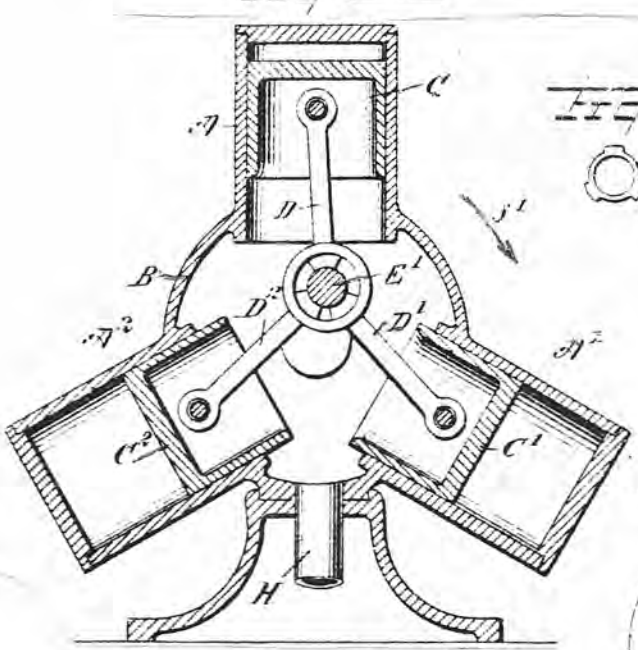


Fig 4

Fig 5

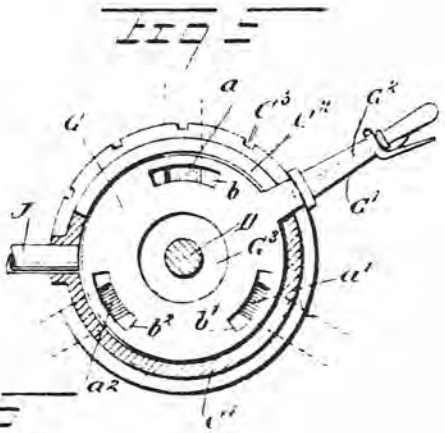
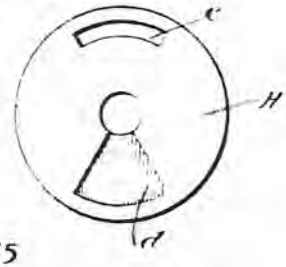


Fig 6



INVENTOR
Joseph T. Fenton
BY Raymond
ATTORNEYS

H. Walker
Geo. J. Hoskins

75

STIRLING CYCLE EXPANSION ENGINES

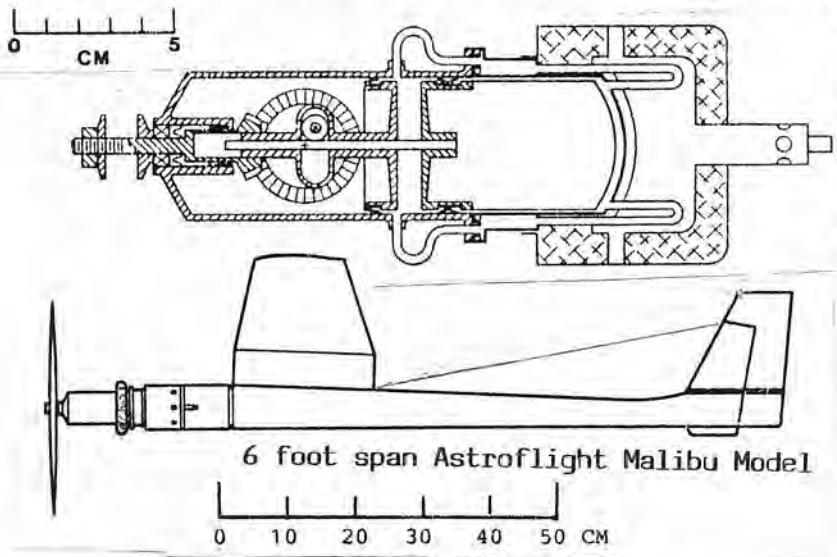
The heat cycle engine was conceived in the 1700s,but earned its name from a Scottish minister, Robert Stirling. Robert & his brother patented & manufactured these heat engines for industrial use. All Stirling cycle engines by definition employ external heat rather than internal combustion as in gasoline & diesel engines. The thermal efficiency of these Stirling engines is better than steam & gasoline engines; & the top diesel efficiency is not as high as the better Stirling engines which attain 38%. Numerous others manufactured many types of Stirling engines for many uses. They pumped water for the cattle herds on the western plains of the United States. They ran dentist's drills, cream separators, boats, even pop corn wagons! A man named Ericson who was noted for designing the Civil War ship the Monitor manufactured many Stirling engines of smaller size. His experiment with a 2,200 ton ship powered with a huge Stirling engine having 14 foot diameter cylinders did not have the success of his smaller engines. Rural electrification & the gasoline engine spelled the demise of the Stirling engines until recently. The dwindling world oil supply has caused the efficient Stirling engines to be re-examined. Accelerated computer aided design,(C.A.D.) has produced exciting results for military & space applications. N.A.S.A. has compiled a bibliography on Stirling engines. Stirling power is available for producing electric power for mobile homes away from electric power lines.

The automobile companys are reported to have experimental Stirling powered automobiles in various stages of development including a few on the test tracks. The availability of improved heat resistant stainless steels & ceramic materials assures the success of the experiments but not necessarily the commercial acceptance due to the higher costs of these exotic materials.

One Canadian experimenter has made a model airplane Stirling engine by combining two model Wankel engines. Flight results are not know at press time.

However a most successful model aiplane powered with a Stirling engine of his own design has been made by Mr. Rob McConaghy of Washington State. I have seen this remarkable engine & held it in my hands. I also have a video tape showing the R.C. Astroflight model with the electric equipment replaced with McConaghy's compact but powerful pressurized Stirling engine flying high & long. Fuel for 6 minutes takes the model for at least that length of flight. McConaghy's third engine was the one with which he was able to achieve these results. He is working on a forth engine design with which he hopes to improve the results.

The operation of the engine in the sectional view below may become more clear when I explain that there are TWO large bevel gears facing each other. They are driven by two Scotch yokes by bearings mounted on the bevel gears. The bearings are arranged so that the pistons will operate like an accordian. One piston drives one bevel gear & the other piston drives the opposite bevel gear in opposite directions of rotation. Both bevel gears drive the small bevel pinion which rotates the propeller shaft which has a seal to maintain the internal pressure. The other view shows Mr. McConaghy's remarkable engine mounted on the nose of the model. A Cannon 2 channel radio was used.



Any person who is interested in learning more about these most interesting Stirling engines can start with the book entitled—"Stirling Cycle Engines" by Andy Ross. This book is obtainable from Solar Engines, P.O.Box 15625 Phoenix, AZ. 850 60. (Tell them that "Bert" sent you!)

No.	Name	Company	Country	No.Cyl.	Bore	Stroke	Disp.	Grams Wt.	Remarks
1	Nomie		USA	3					Also used with compressed air, rotary
2	Nomie		USA	6				450	Also used with compressed air, rotary
3	Nomie		USA	8					Also used with compressed air, rotary
4	Bates Gyroette,	Howard engine Co	USA	6	.69"	.875"	$1.95"^3$	283	Also used with compressed air, rotary
5	Cetonia		France	8	19mm	28mm	63.5cc	780	Used H_2O heat exchanger, radial
6	Fieux Moteurs		France	2	10mm	25mm	3.9cc		Rotary, with pressure reduction valve
7	Fieux Moteurs		France	3	10mm	25mm	5.9cc	57	Rotary, with pressure reduction valve
8	Fieux Moteurs		France	5	10mm	25mm	9.8cc	71	Rotary, with pressure reduction valve
9	Zero-4	Micromoteur	France	1					Radial, ball valve 8 gm. cartridge
10	DP-03		USSR	1	7mm	7mm	.27cc	22	Radial, ball valve tank 4.4cc
11	Modela	Modela	CSSR	1	7mm	7mm	.27cc	25	Radial, ball valve tank 4.5cc
12	Keil Kraft	Keil Kraft	UK	1	.25"	.30"	$.0147"^3$	53	Radial, ball valve Sparklet cartridge used 8gm.
13	Weston		UK	1					Radial, ball valve (1948 rare)
14	Shark	Harden	UK	1	4.6mm	4.65mm	.077cc	13	Radial, ball valve 1 tank-- 3.2cc
15	Shark Contest	Harden	UK	1	4.6mm	4.65mm	.077cc	13	Radial, ball valve 1 tank-- 3.2cc
16	Shark G T	Harden	UK	1	4.6mm	4.65mm	.077cc	18	Radial, ball valve 2 tanks- 3.2cc each
17	Shark Twin	Harden	UK	2	4.6mm	4.65mm	.077cc	24	Radial, ball valve 2 tanks- 3.2cc each
18	Brown .005	Brown	USA	1	.179"	.179"	$.005"^3$	8	Radial, ball valve tank 3.0cc
19	Humbrol Mach II	Humbrol	UK	1	4.6mm	4.65mm	.077cc	14	Radial, ball valve vertical integral tank 3.1cc
20	Telco	Telco	UK	1	4.5mm	3.8mm	.06cc	13	Radial, ball valve tank 2.8cc
21	Turbotank 3,000	Telco	UK	1	4.5mm	3.8mm	.06cc	19	Radial, ball valve tank 3cc integral
22	Turbotank 6,000	Telco	UK	1	4.5mm	3.8mm	.06cc	22	Radial, ball valve tank 6cc integral
23	Gnat	Telco	UK	1					Radial, ball valve
24	Cox .020	Carbonic Motors	USA	1			$.02"^3$	31	Radial, ball valve, conversion from gas engine, tank 10cc
25	Cox .049	Carbonic Motors	USA	1	.406"		$.049"^3$	62	Radial, ball valve, conversion from gas engine, tank 20cc
26	Denton	Denton Motors	USA	1	.328"	.40"	$.034"^3$	51	Radial, ball valve Sparklet cartridge used, 12gm.
27	OK	Herkimer	USA	1	.275"	.31"	$.018"^3$	38	Radial, ball valve Sparklet
28	A-100	Campus	USA	1	.125"	.125"	$.0015"^3$	8	Radial, ball valve tank 5/16" dia.x 2"long, 3 types
29	Bee	Campus	USA	1	.187"	.187"	$.0051"^3$	18	Radial, ball valve tank 3/8" dia.x 3"long
30	Buzz	America's Hobby Ctr.Inc.	USA	1	.187"	.187"	$.0051"^3$	16	Radial, ball valve tank 5/16" dia.x 4"long
31	Campus A-23	Brown	USA	1	3.07mm	3.25mm	.023cc	6	Radial, ball valve peanut engine
32	Campus Bee	Brown	USA	1			.07cc	13	Radial, ball valve tank 6cc
33	MJ Bee 140	Brown	USA	2			.140cc	19	Radial, ball valve tank 10cc
34	Campus 80	Brown	USA	1			.08cc		Radial, ball valve Numbers 34 & 35 were not
35	Campus 160	Brown	USA	2			.16cc		Radial, ball valve put into production.
36	MJ 70	Brown	USA	1			.07cc	9	Radial, ball valve tank 3cc
37	MJ 140	Brown	USA	2			.140cc	15	Radial, ball valve tank 3cc or 6cc
38	Hitek Racing	Pewa	Swiss	1	4mm		.075cc	99	Radial, ball valve model cars, tank 10cc
39	G-3-1991	Gasparin	Czech	1	2mm	1.2mm	$3.2mm^3$	1.8	15.75 engines = 1oz. World's smallest!
40	G-5-1991	Gasparin	Czech	1	2mm	1.7mm	$5.3mm^3$	2.0	14.17 engines = 1oz.
41	G-6-1990	Gasparin	Czech	1	2mm	2.0mm	$6.3mm^3$	2.8	10.32 engines = 1oz. Apparently 1st of series.
42	G-12-1991	Gasparin	Czech	1	2.5mm	2.4mm	$11.8mm^3$	3.2	8.86 engines = 1oz.

Note: This listing was compiled from a variety of sources including manufacturers' literature, engine measurements, lists from other people. There may be some omissions & errors. The author would appreciate being advised of such matters for future reference. Thank you.

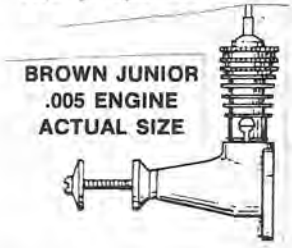
CO_2 EXPANSION ENGINES

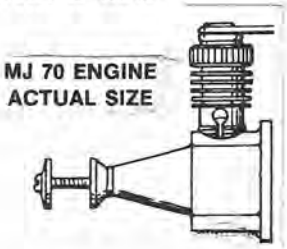
First let us examine the properties of CO_2 & air. At the same standard conditions, CO_2 has a specific gravity of 1.529 times that of air. Also the viscocity of air at 68°F. 183 micropoises & CO_2 is 148 micropoises. These factors mean that the CO_2 is not only heavier than air but would waste by leakage more than air. Another problem with CO_2 is that it becomes a mildly corrosive acid when it is dissolved in water. If CO_2 engines are not made of noncorrosive materials, they should be well oiled & wiped dry of any moisture.

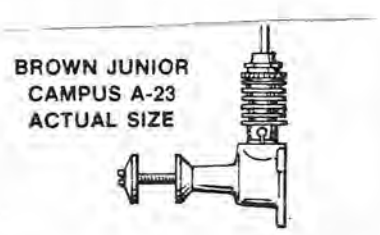
The last two issues of "Flying Aces Club News" in 1987 had very good articles on CO_2 model aircraft by Jon Zeisloft. Jon suggested the use of gun oil in CO_2 engines. Guns must fire no matter what the temperature may be. One brand name of a gun oil is "Triflon". Zeisloft advised placing the filler nozzle or charging nozzle at a high location on the mdel which is well braced since forces applied during the filling operation are often quite large. The placement of the tank is very important. It should be located such that air can circulate freely around the whole tank in order to acquire heat from the air to partially regain some of the heat lost by the expansion of the CO_2. The outlet of the tank should be on top & with the tank center line within 30° of vertical. These factors help to be able to get a "liquid charge" into the tank. Jon cautions never use sandpaper or anything which could allow small particles to enter the tubing when repairing or hooking up the CO_2 system. Try to avoid making burrs.

Bill Hannan of Hannan's Runway cites these advantages of CO_2 :- 1. One flip starting; 2. Most run in either direction of rotation; 3. Quiet in operation; 4. No batteries to keep charged just so; 5. Models do notneed heavy fuel proof doping; 6. Propeller pitch & diameter may vary through a wide range as long as the propeller has sufficient flywheel mass to operate the ball valve; 7. R.P.M. may be varied more or less easily depending upon the location & type of the adjustment provided. Disadvantages of CO_2 include:- 1. The small tubing is easily kinked & damaged; 2. CO_2 power does not work in cold weather because the pressure becomes too low & 'dry ice' forms in the system; 3. The high pressures involved with CO_2 mandate that extreme caution be used when operating such equipment.

The engines illustrated below are actual size. They are the well know Brown engines. The only missing engine is the twin. It resembles the MJ 70 if the second cylinder is added to the picture. Note that these engines all hold the propeller by means of a small screw threaded into the crankshaft rather than having the crankshaft extend through the propeller & hold the propeller with a nut.



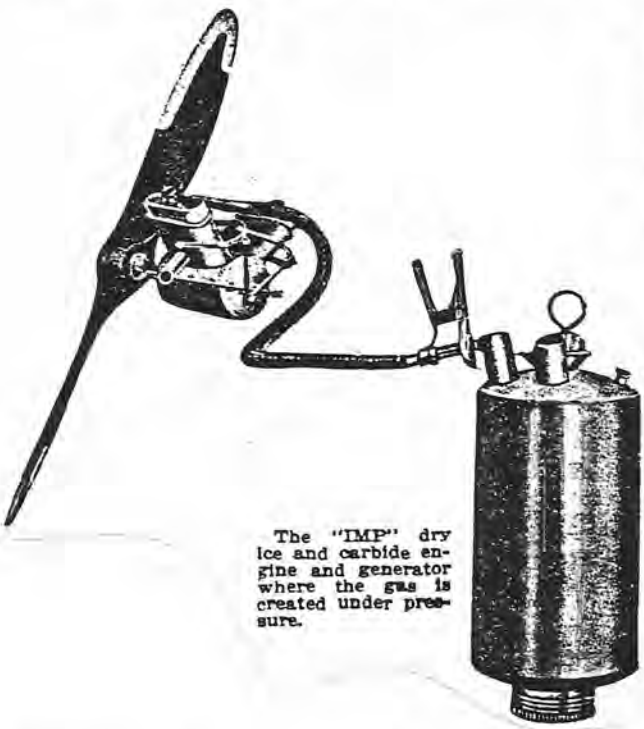




What about the CO_2 ? "Sparklets", small steel bottles of CO_2, were formerly used on board the early CO_2 model aircraft. Because of weight, they have been replaced by lighter aluminum tanks. "Sparklets" are now used to charge the on board aluminum tanks. Some model fliers use a much larger supply tank. These larger supply tanks last for many flights & may be refilled at fire extinguisher dealers & welding supply stores. Several engines made in Japan are not listed on page 77. They could be operated with COMPRESSED AIR, CO_2 or an odd mixture of gasses made by a "Generator". See page 79. These engines were made of very thin steel held together with bent tabs. The gas generator was the most unique feature of these power plants. Three different materials were loaded into as many separate places on the unit.

The valve action on these engines was at the cylinder head so that there was no waste of "fuel" between the valve & the cylinders.

A measured amount of water plus pellets of carbide & dry ice were placed in their proper cubicles & sealed. Then the tank was connected to the engine & the contents were dumped together. The heat from the carbide & water reaction turned the dry ice into CO_2 gas. The carbide & water, besides producing heat, made acetylene gas ($HC{-}{-}CH_3$), water vapor & residue which had a very foul odor. Most people did not like to clean the mess after each running of the engine. Getting all of the ingredients together at one time was also a challenge. You had few if any model supply stores; & the corner grocery did not carry carbide or dry ice. So these Imps are collectors' items only, today. COMPRESSED AIR tanks were available. A 2-3/4" diameter x 24" long tank with the two cylinder Imp engine weighed 12 ounces. A 4" diameter x 30" long outfit weighed only 19 ounces.



The "IMP" dry ice and carbide engine and generator where the gas is created under pressure.

You can see in the illustration the clip for enabling the generator to be removed for charging & cleaning & quickly connected again. The slide valves in the cylinder heads could be oiled through screw caps in the covers. The thin tin coated steel was subject to dents & rust. However, as you can see the Imp did resemble a "Vee" engine & had appeal to the purchaser.

Looking at the top of the chart we see 3 sizes of Nomie engines-a 3 cylinder, a 6 & an 8. The brass cylinders have fine threads at each end which screw into the clinder heads & the crankcase. These engines are rotary with the propeller attached to the front of the crankcase. They were quite powerful but used large amounts of CO_2 (or compressed air). A bracket supported the hollow stationary crankshaft with the weight of the engine being at the end of a long cantilever beam. This made these engines quite vulnerable to damage. They were sold both as casting kits & assembled.

The Bates Gyroette was quite similar in appearance to the Nomie. It had curved tubes from the valve to the cylinder heads & a different mounting bracket. They were both made in Chicago about 1912. (See pages 70 & 73.)

The Fieux engines were a very clever idea embodying a pressure regulator. But in actual practice, this regulation reduces the "take-off" initial power needed to gain altitude. The springs & valve add weight. The Fieux did make models fly, but not nearly as well as anticipated. The Fieux was made in three sizes too,-a 2, 3 & a 5 cylinder. The 3 cylinder model is illustrated below.

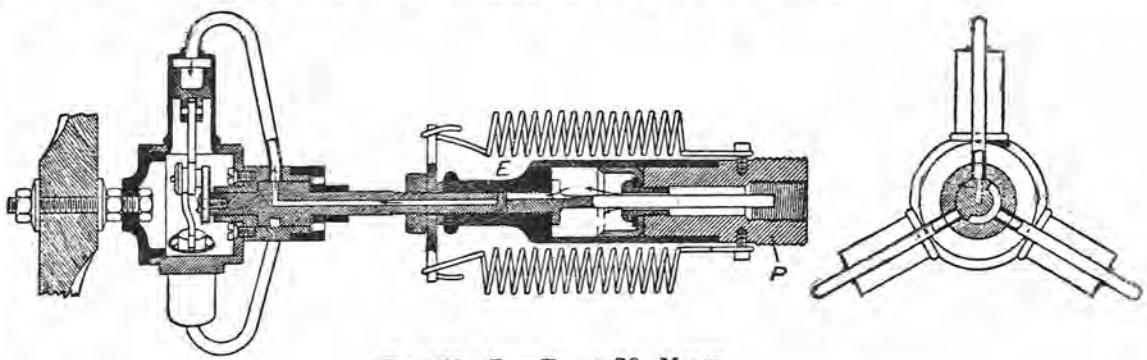
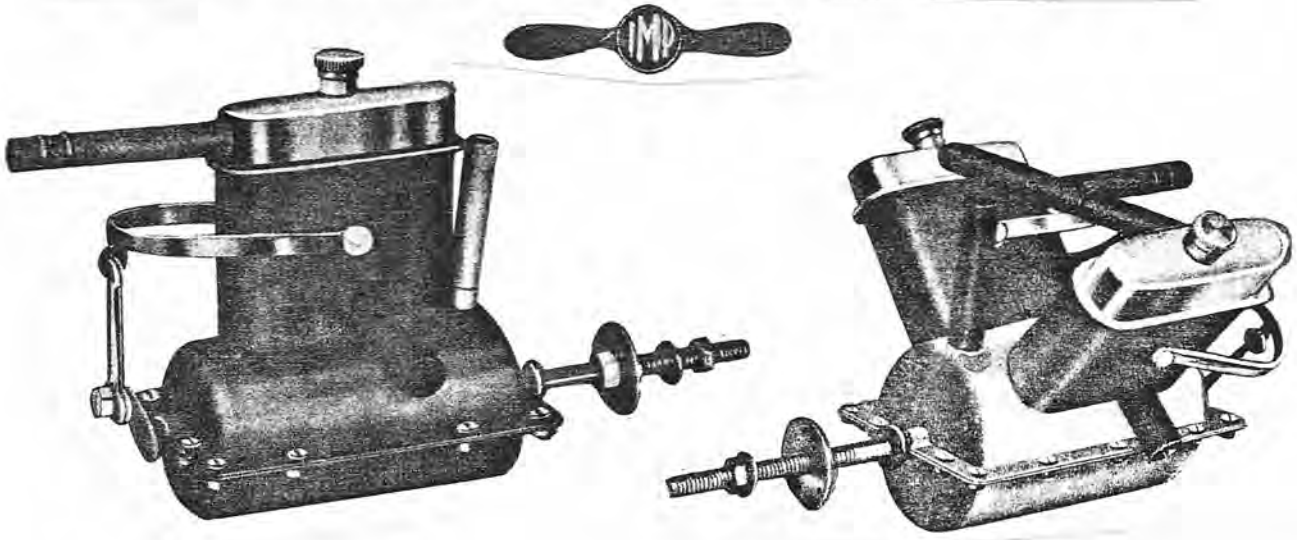


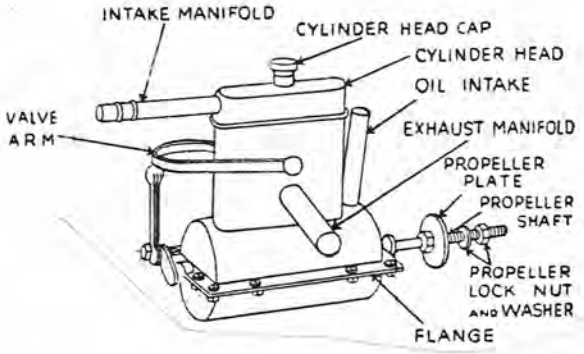
FIG. 129.—THE FIEUX CO_2 MOTOR.

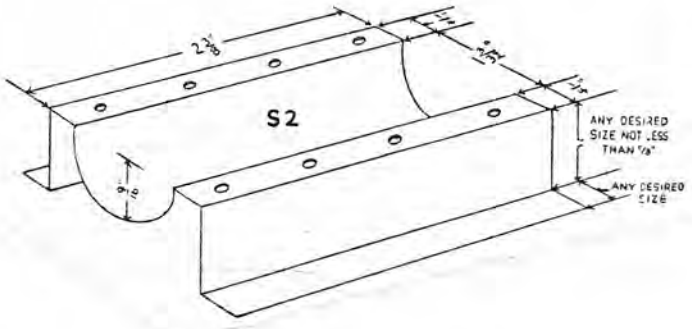
The "Sparklet" is inserted in the right end in part labeled *'P'*.

IMP TORNADO MOTORS



Model S 2





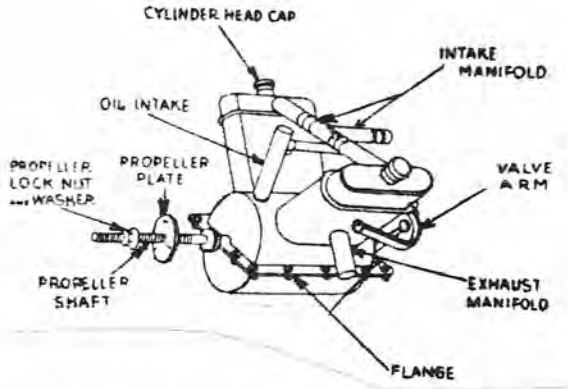
The following measurements will indicate the small space required to install the "IMP" TORNADO Motor, Model S-2, in any type Model Airplane:

—3¼in. This is the overall length of Motor and is minimum clearance between nose and first bulkhead in fuselage.

—2¾ in. This is overall height of Motor from bottom of crank case to top of cylinder head cap.

—1½ in. This is width of Motor at flange and is minimum which must be allowed inside fuselage.

Model V 4

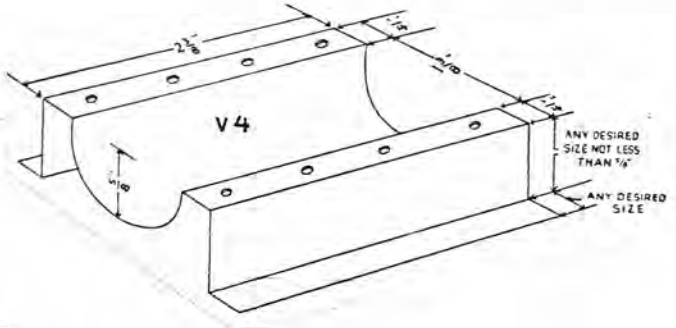


The following measurements will indicate the small space required to install the "IMP" TORNADO Motor, Model V-4, in any type of Model Airplane:

-3¼ in. This is overall length of Motor and is minimum clearance which must be allowed between nose and first bulkhead of fuselage.

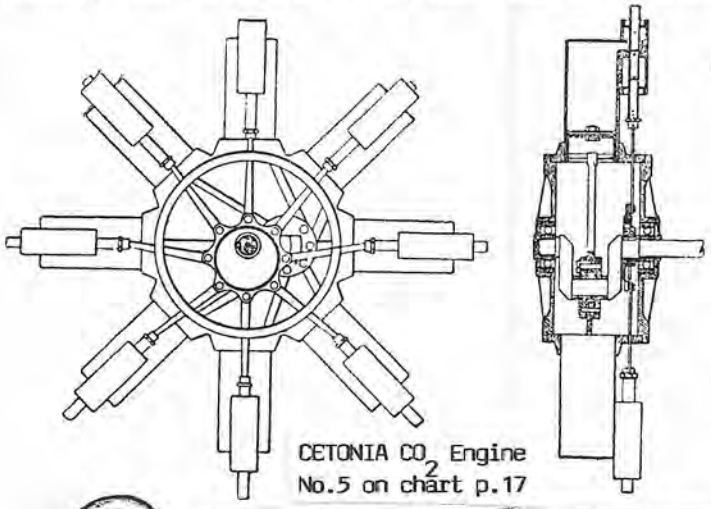
-2¾ in. This is overall height of Motor from bottom of crank case to top of cylinder head caps.

-3¾ in. This is width of Motor at widest point, across top, and is minimum space which must be allowed in fuselage. This Motor is 1¾ in. wide at the flange.



Since the Fieux engines are rotary, the cylinders revolve. In addition the springs & the pressure regulating valve & CO_2 cartridge move in their operation. This means that there is no good place to mount the engine except on the small length of tube to the left of the spring support & to the right of the valve box. This mounting would seem to be an inadequate feature of the Fieux engines.

Another very early engine of 1911 vintage is the Cetonia, #5 on the chart. This is an 8 cylinder radial engine. It is well engineered. In the cross section drawing, the ball bearing crankshaft indicates the quality of the design & workmanship. A friend, Tom Crompton of England has #49 Cetonia. He sent me his nice sketch of the Cetonia which I am happy to share with you. The Cetonia was used in French prototype aeronautical model experiments with considerable success. The engine flew a 38.6 lb. model biplane model at a height of about 33 feet for a distance of 3,865 feet. The small curved vane directly behind the propeller is not explained. A possible explanation is that it may be a gadget for compensating for the engine torque.

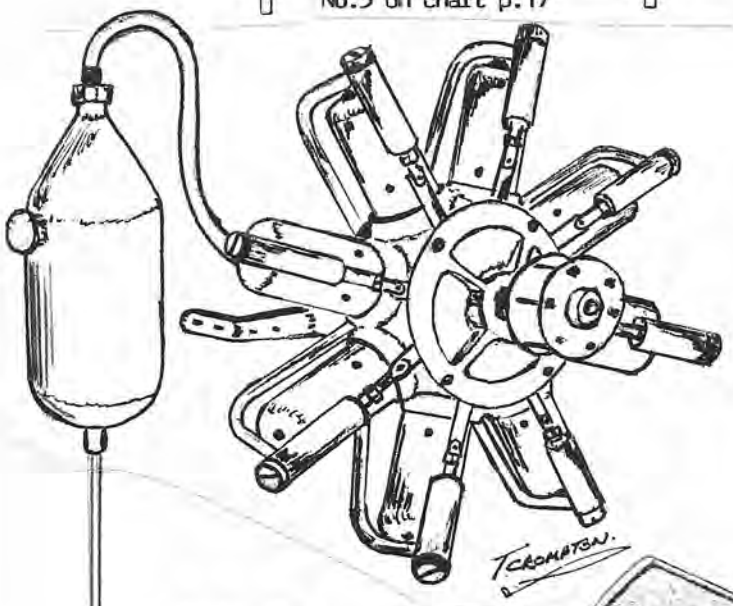


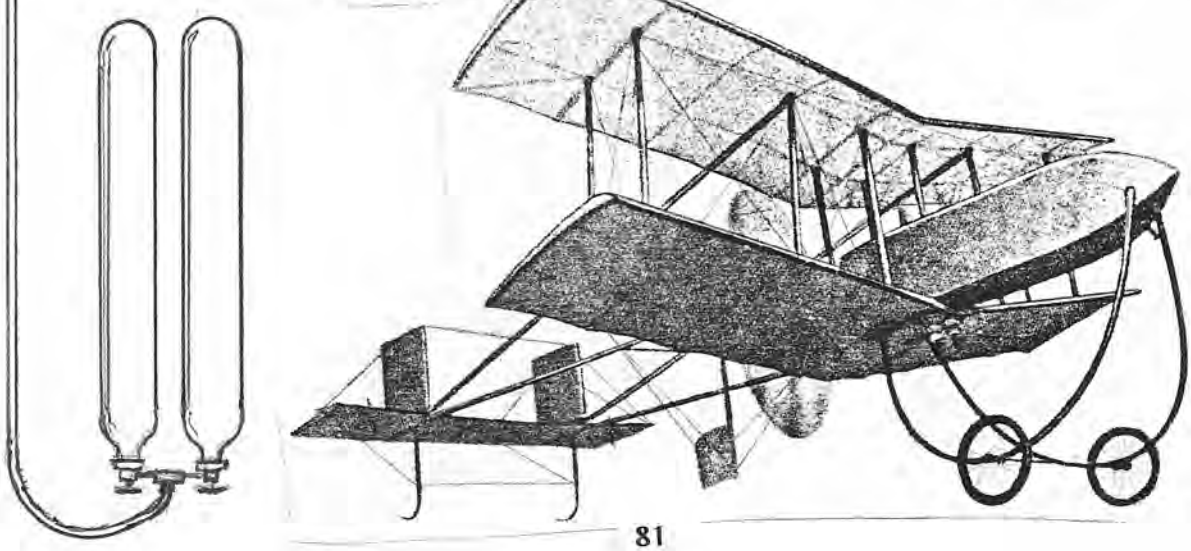
CETONIA CO_2 Engine
No.5 on chart p.17

The V. E. Johnson book, Model Aeroplaning, pictures another Cetonia powered model which was built by a Mr. Goodall. The model was 8 feet long & had a wing span of 126". The wing had a birdlike shape in the plan view. It was a seaplane, floating on 3 flat rectangular floats. Mr. Johnson tells of 2 attempts to fly the model off of water. Due to a leak in the CO_2 system, the trial was finally abandoned.

These are the only two Cetonia models that have come to my attention.

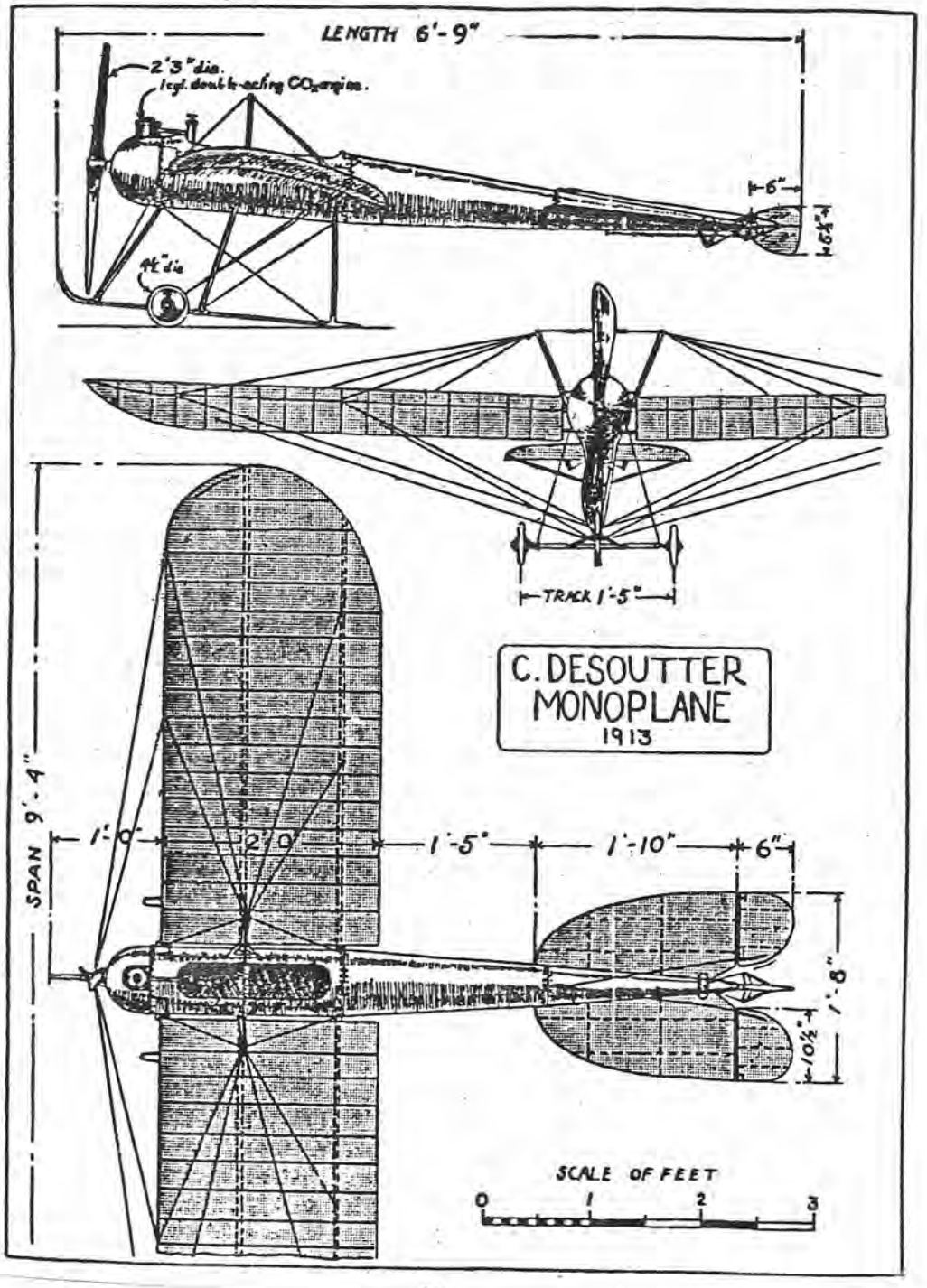
From the sizes of these 2 ships, you can have some idea of the power of the Cetonia engine.





The C. DESOUTTER CO_2 1913 Monoplane.

This large CO_2 model would be at home at any of today's big ship events with its wing spread of 112". The engine was a single cylinder double acting unit about which very little technical data seems to be available.
The engine drove a 27" diameter propeller.
The plan appeared in the November 8, 1913 issue of the English magazine "Flight."
The model was very streamlined for its vintage. The rudder would seem to be of very small area for satisfactory lateral stability.
The meager details of the model include the fact that the fuselage was made in three sections screwed together. The sections were aluminum alloy.
My 1922 V.E.Johnon book has 3 pictures, one without covering, one with covering & one showing the model flying.



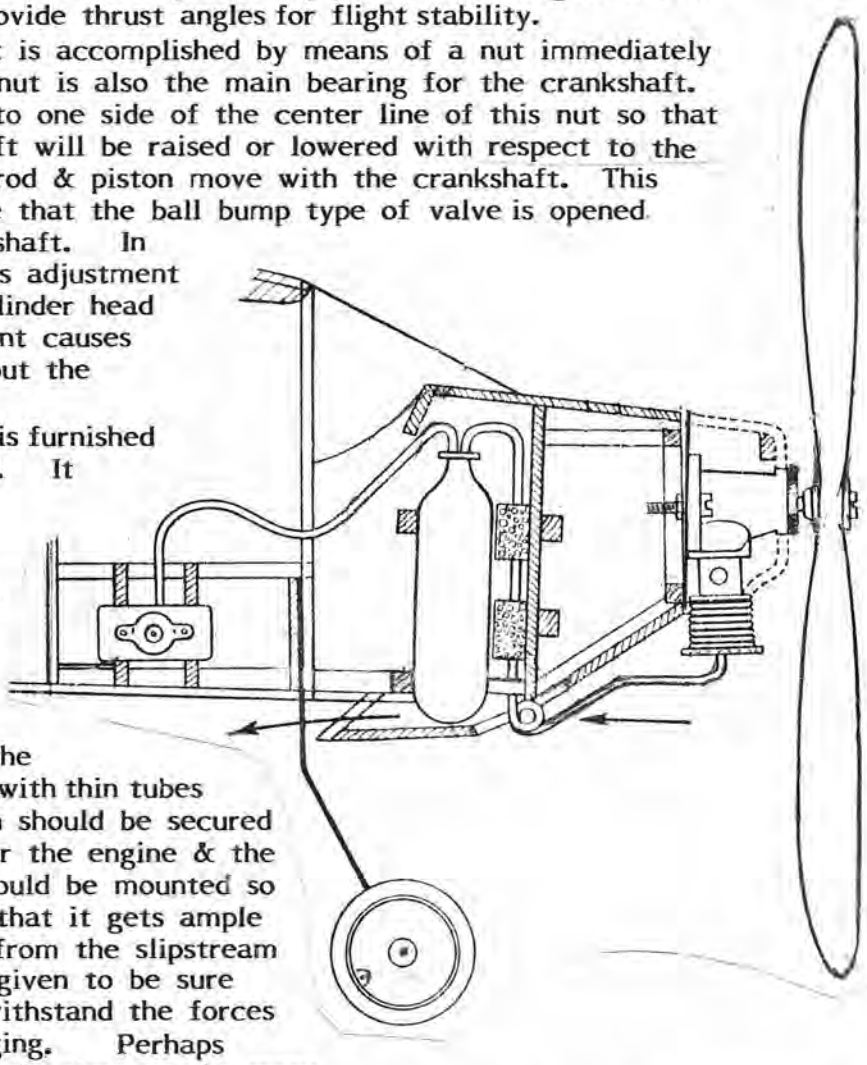
CO_2 Engine by Telco

A suggested typical installation for this English CO_2 engine as diagramed on the box is given below. This installation seems to have both good & bad features. This mount seems to provide all of the requirements for a tractor type of model to fly properly. The upright position of the tank allows a liquid fill to be accomplished. The coiled heat pickup tube just in front of the lower end of the CO_2 tank hopefully absorbs heat from the slip stream air in sufficient quantity to prevent the formation of CO_2 snow or "Dry ice" from forming in the tubes & slowing or even stopping the engine. All of this suggests that CO_2 engines may not operate very well on a cool day. In addition Telco suggests that air path be provided to allow air from the slip stream to circulate around the CO_2 tank to improve the performance of the system. In that connection, padding around the tank used in mounting should cover the least possible area to keep heat recovery area of tank at the maximum.

Note in the typical installation diagram that the three items-motor, tank & filler nozzle - are one unit though with flexible tubes between the parts. The three parts have to be individually mounted securely without kinking the thin tubes. Some thought should be given to the problem beforehand to make certain that the parts, especially the tubes, will not be damaged. The upright position of the tank can be allowed to be off of vertical by as much as 45° without serious problems.

The engine itself is mounted on a thin piece of plywood so arranged that the engine can be shifted to provide thrust angles for flight stability.

The speed-power adjustment is accomplished by means of a nut immediately behind the propeller. This nut is also the main bearing for the crankshaft. The crankshaft is mounted to one side of the center line of this nut so that by rotating the nut the shaft will be raised or lowered with respect to the cylinder. The connecting rod & piston move with the crankshaft. This motion changes the distance that the ball bump type of valve is opened each revolution of the crankshaft. In some other CO_2 engines this adjustment is made by screwing the cylinder head in or out. This arrangement causes some twisting of the tube but the Telco scheme does not.



The plastic propeller which is furnished appears to be well designed. It had broad tips which are swept forward slightly to move air more straight or in line with the axis of the engine. The outer ends of the blades are wide where the most work is being done.

In the installation sketch, the three units strung together with thin tubes are a bit vulnerable. Each should be secured using the screws supplied for the engine & the filler nozzle. The tank should be mounted so that it can not move & so that it gets ample air circulation to add heat from the slipstream Special attention should be given to be sure that the filler nozzle will withstand the forces it is subjected to in recharging. Perhaps locating one side of the nozzle close to the more substantial landing gear attachment point would tend to provide greater rigidity. Some of the "scaffolding" for mounting this essential gadget appears to be a bit fragile in the diagram.

Once installed in a model it would seem that removal for any purpose would be quite a chore. Making the whole power plant as one easily removed assembly deserves a bit of consideration.

The MacFarland Radial Engine.

Fred S. MacFarland & his partner named Stevens produced an unknown quantity of a rather unusual expansion engine. Since there are a few of these engines in collections, I would be negligent if I did not provide a description of it.

The engine had 5 cylinders mounted on an enclosed crankcase. The cylinders each had 5 fins around the body & 9 fins on the cylinderhead. The overall diameter of the engine was 2-1/2". The bore was 3/8" & the stroke was 1/4".

The motor had a very "clean" appearance because there were no spark plugs or glow plugs. There were no timers or rocker arms. There was no carburetor.

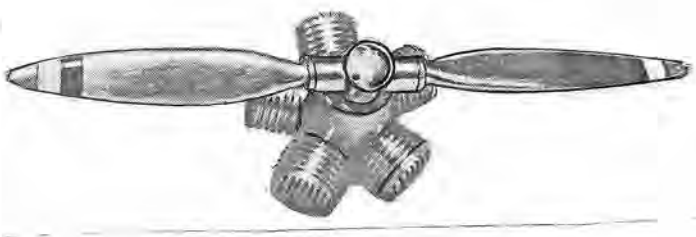
The motor was equipped with an adjustable pitch propeller of 9" diameter.

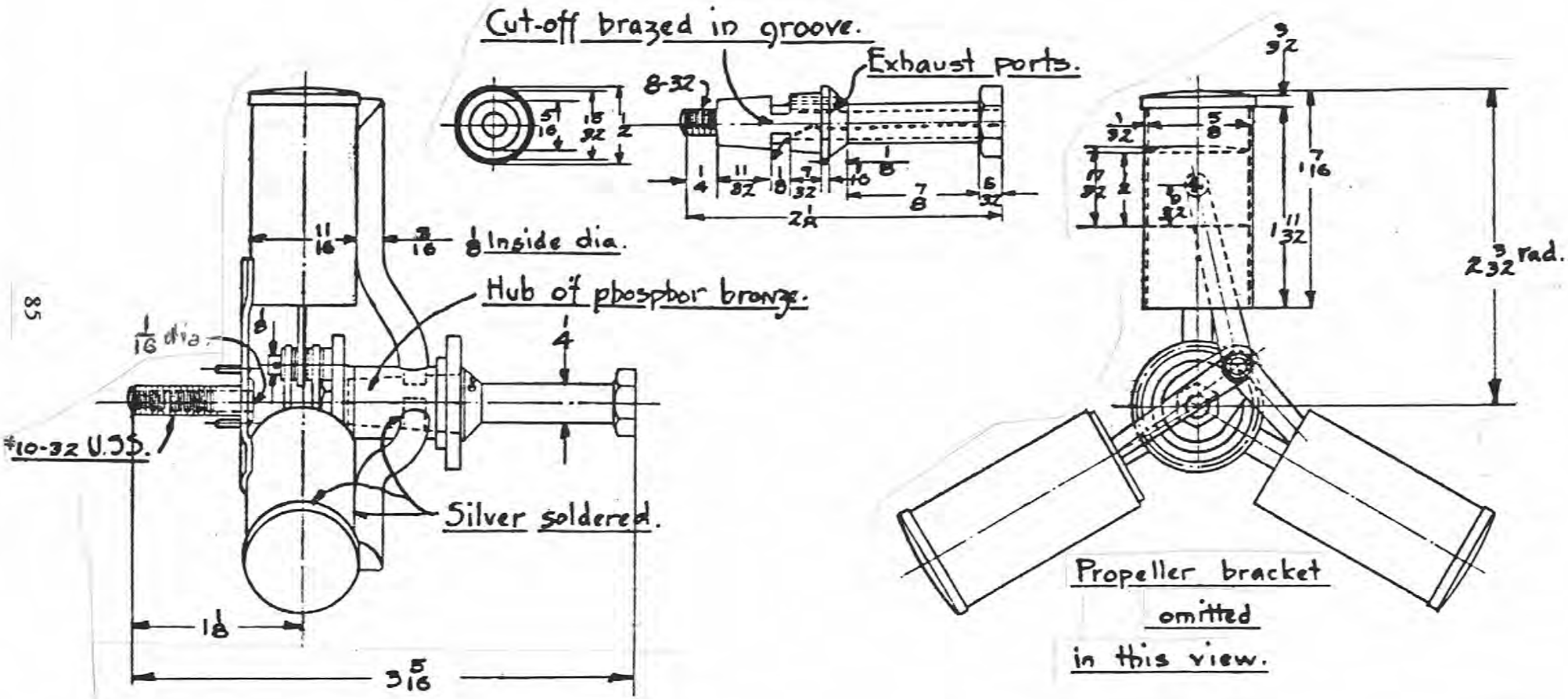
The unusual feature of this engine was the source of pressure which was used to operate it. A stick of pyrotechnic material or rocket type of fuel was ignited first & then it was inserted into a tube directly behind & connected to the engine. Then the tube was sealed quickly with a 90° turn locking cap. The pressure of the gasses from the burning rocket material ran the engine until the stick was fully consumed.

The combined weight of the engine, propeller, pressure tube & sealing cap was 8 ounces. This big power plant was installed in a small 24" wing span Lockheed Vega scale model. 24" models of other airplanes were planned but apparently never made.

Adding the weight of the model to the weight of the power plant would require that the model would have to fly quite rapidly in order to remain airborn.

There were too many problems which were not solved for this engine & 24" span plane to be successful. Rate of burning of the rocket material was difficult to control. Keeping the engine lubricated in the presence of the hot & corrosive products of combustion was surely a problem. These & other problems account for the demise of this MacFarland & Stevens project.





3 Cylinder Rotary Engine.

This rotary engine drawing appears to be rather simple. However as usual, there will be some problems in the fabrication & assembly of the parts. For example, the propeller bracket may be difficult to locate exactly on the true centerline of rotation. One way to solve this problem would be to drill a 1/16" diameter hole in the main shaft about 1/2" deep & use a 1/16" diameter pin 3" or 4" long through the propeller shaft on the bracket as a locater while soldering the prop. bracket to the cylinders. The pin can then be removed.

In order to keep the cantilever overhang as short as possible, it may be desirable to diminish length 3-5/16" dimension by 1/2", or 2-13/16". This would save a little weight as well.
The 11/16" diameter cylinders would provide a very powerful engine with high torque & air consumption. If cylinders were in the range of 7/16' to 1/2" diameter, the engine would have the power to fly 5 to 8 foot wingspread ships. K. & S. 1/64" wall brass tube is suggested for the cylinders & air pipes. This engine appears to have straddle or twin rods on the two lower cylinders. Single rods would make assembly easier. Fit all parts closely & you should have a good rotary runner.

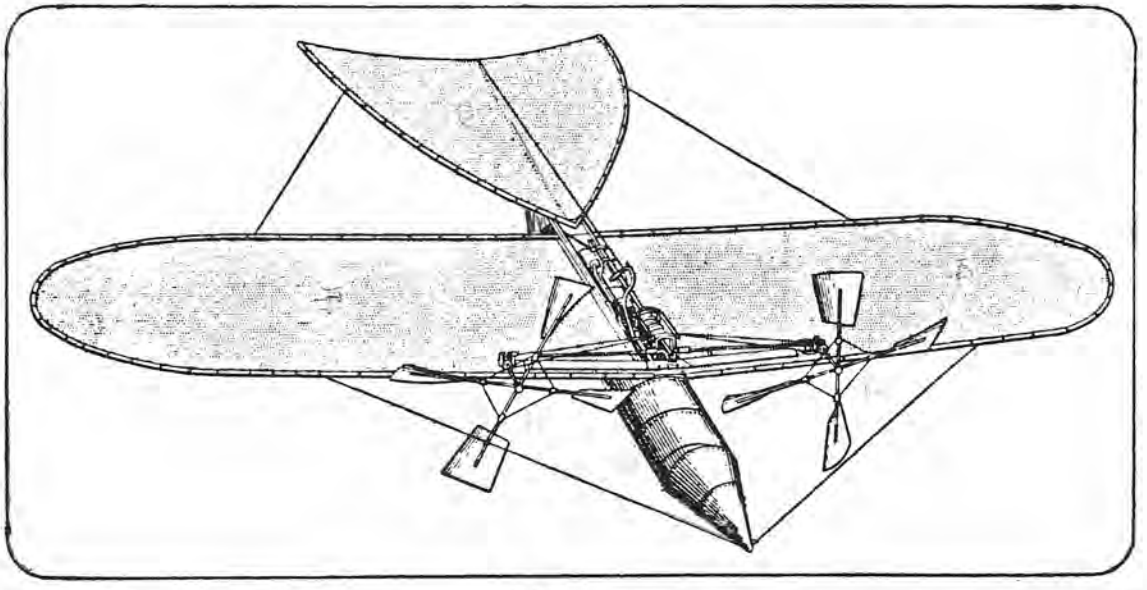
Victor Tatin's COMPRESSED AIR Model Airplane

Well over 100 years ago while men were mostly just dreaming of flying, Victor Tatin awakened the world to the actual possibility that man would fly. In 1879, Tatin constructed & flew a COMPRESSED AIR powered model aircraft. This model was a counterpart of a modern twin tractor monoplane in many ways. His experiments were a quantum leap in the state of the art.

Earlier experimenters such as Sir George Cayley built & flew a 140 pound 300 square foot glider for short distances in 1808. Then another earlier pair- Henson & Stringfellow- together experimented with a model which was found to be too unstable. However Stringfellow built an expansion engine steam powered model which he flew for "about 40 yards" in 1846. This 6-1/2 pound model was launched off of an inclined tight wire giving the model some advantage of height at start of flight.

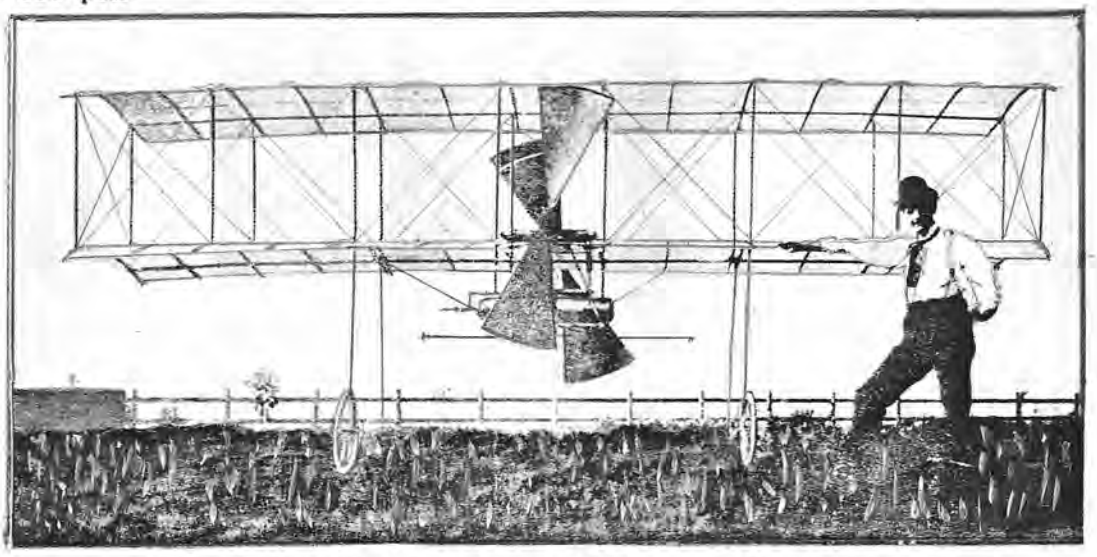
Tatin's model on the other hand arose from the ground. It was tethered to fly in a circle 46 feet in diameter. It requires more energy to fly in a circle than to fly in a straight line. Tatin's model is worthy of more detailed description. Wing span was 72 Inches. Wing chord was 16 inches. Covering material was silk. Fuselage or body was an air tank. Thin steel strip wound in a spiral formed cylindrical portion of reservoir. Ends were conical. Tank-fuselage was 4 inches in diameter & 36" long. Total weight of tank was only 1-1/2 pounds although it was strong enough to withstand a pressure of 294 pounds per square inch. A silk covered horizontal tail stabilizer was attached to rear of tank. A single cylinder oscillating engine drove twin 4 bladed propellers by a shaft & bevel gearing. Blades on propellers were placed at some distance out from hub where they are more efficient. Tatin's model was lightly constructed weighing only 3.85 pounds. Measurements & calculations including 18 mile per hour air speed showed that Tatin's machine carried a loading when airborn at a rate of 110 pounds per horsepower.

From his experiments, Tatin concluded rightly that larger aircraft would be practical. However he lacked funds for such a more expensive undertaking. Tatin's successful flight results with his COMPRESSED AIR powered model did encourage others to advance the state of the art.



COMPRESSED AIR POWERED AIPLANE CARRIES MAN IN 1898.

A thesis "The Flying Machine as a Mechanical Engineering Problem" by August M. Herring was refused by Stevens Institute. As a result young Herring left school & was never graduated. He decided to prove that flying machines were just another engineering problem to be solved. "Gus" built box kite glider models one of which he flew with a small gasoline engine in 1892. He wrote literally hundreds of articles for popular press as opposed to scientific press. Dr. Langley of Smithsonian hired Herring to assist in Langley's aeronautical experiments. A modification in Langley's flier number 5 by Herring was responsible for improved performance. Herring left to work with Octave Chanute in his gliding research. Herring had ideas of his own. While Chanute was working toward automatic stability, Herring was chafing-at-the-bit to attain dynamic flight by shortest route possible. So "Gus" left Chanute to build his own powered dream ship in Saint Joseph Michigan. His objective was to raise capital by building & flying an aircraft of simplistic design as quickly as possible. His biplane machine as shown below was basically a Chanute type glider with 18 foot wingspread & 54 inch chord. Even with lower wing, Herring mounted a twin opposed COMPRESSED AIR ENGINE. His air supply was an 884 cubic inch tank which was normally charged to 600 psi.



AUGUST HERRING'S COMPRESSED AIR POWERED PLANE

Herring's first engine powered flight was made on October 11 1898 at St. Joseph. Hanging beneath on 2 rails, Herring's COMPRESSED AIR POWERED airplane flew against a 25 mile per hour wind for 267 feet through air & 50 feet over ground. Only one person witnessed this first flight. Again on October 22 1898 ma[illegible]ade a second flight, this time with several reporters & a couple of children as witnesses. This flight bucked a 26 mile per hour breeze for a distance of 350 feet through air & 75 feet over ground with a duration of 9 seconds. This was 5 full years before Wright's first flight with power! It was also three years before Gustave Whitehead's now documented flights.

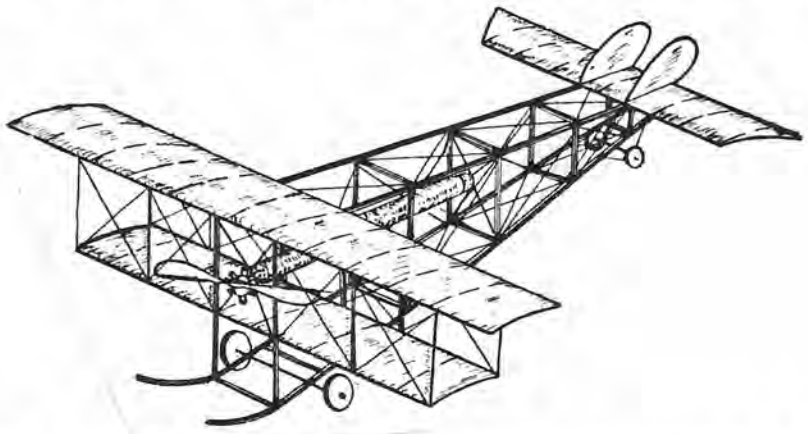
So before the turn of the century man had actually flown in an airplane with COMPRESSED AIR POWER.

It is interesting to note that Herrings application for a patent was refused due to "unproven principles" yet it contained 20 unique patentable features. In 1910 a new director of patents said that there was no reason why a patent should not have been granted. Herring's application for a patent not only explained theory of flight but was backed up with flying models. Wright patent merely patented sticks & wires without any explanation of theory of flight.

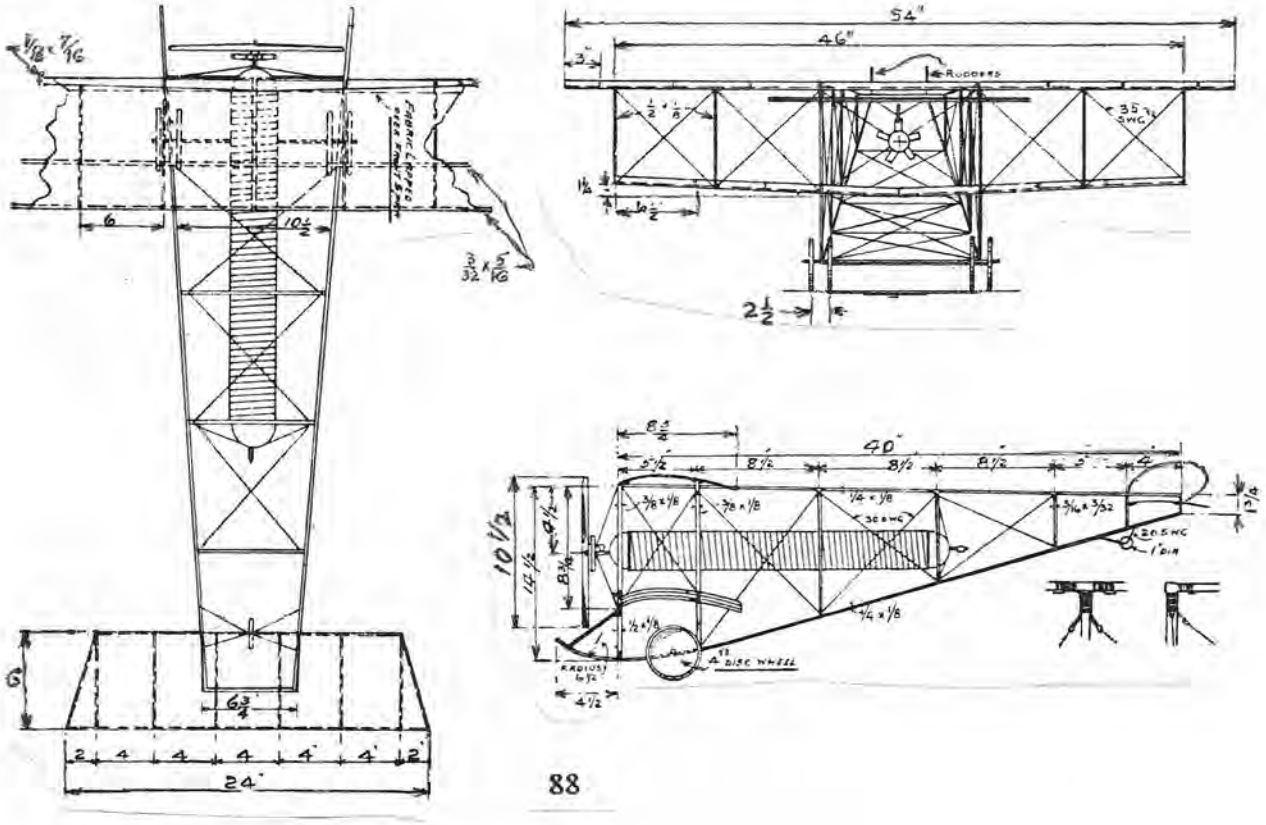
Compressed air planes come in all sizes!

(The engine weighed 12 pounds. Propellers were 5 feet in diameter. Herring supported himself on 2 rails below lower wing & between propellers.)

A 1920 COMPRESSED AIR Model from Cassell's Work Handbook.



This crude biplane model plan is representative of early attempts to fly models with power other than with rubber strands. This ship was powered with a five cylinder rotary engine which weighted the front of the craft. This engine was hung on the front of a 2-3/4" diameter x 24" long shim brass air tank. The total weight of the power plant was 10 ounces. The design of the model was predicated on the thrust available. A thrust test showed that an initial thrust of 4 ounces could be counted on. Then using a lift to drag ratio of 5 to 1 for this type of biplane the designer limited the weight to a maximum of 4 x 5 or 20 ounces. Next with a wing loading of 4 ounces per square foot this required a wing area of 5 square feet which the designer distributed as shown in his plans. If you want to build an antique COMPRESSED AIR model this is one to try. By using balsa for the fuselage, the tail will be lightened. Then by using one of the light weight plastic air tanks, you may be able to balance the long tail & compensate for the heavy 5 cylinder engine used in the original ship. This ship at a contest would certainly shake up the spectators!



Corben COMPRESSED AIR Model.

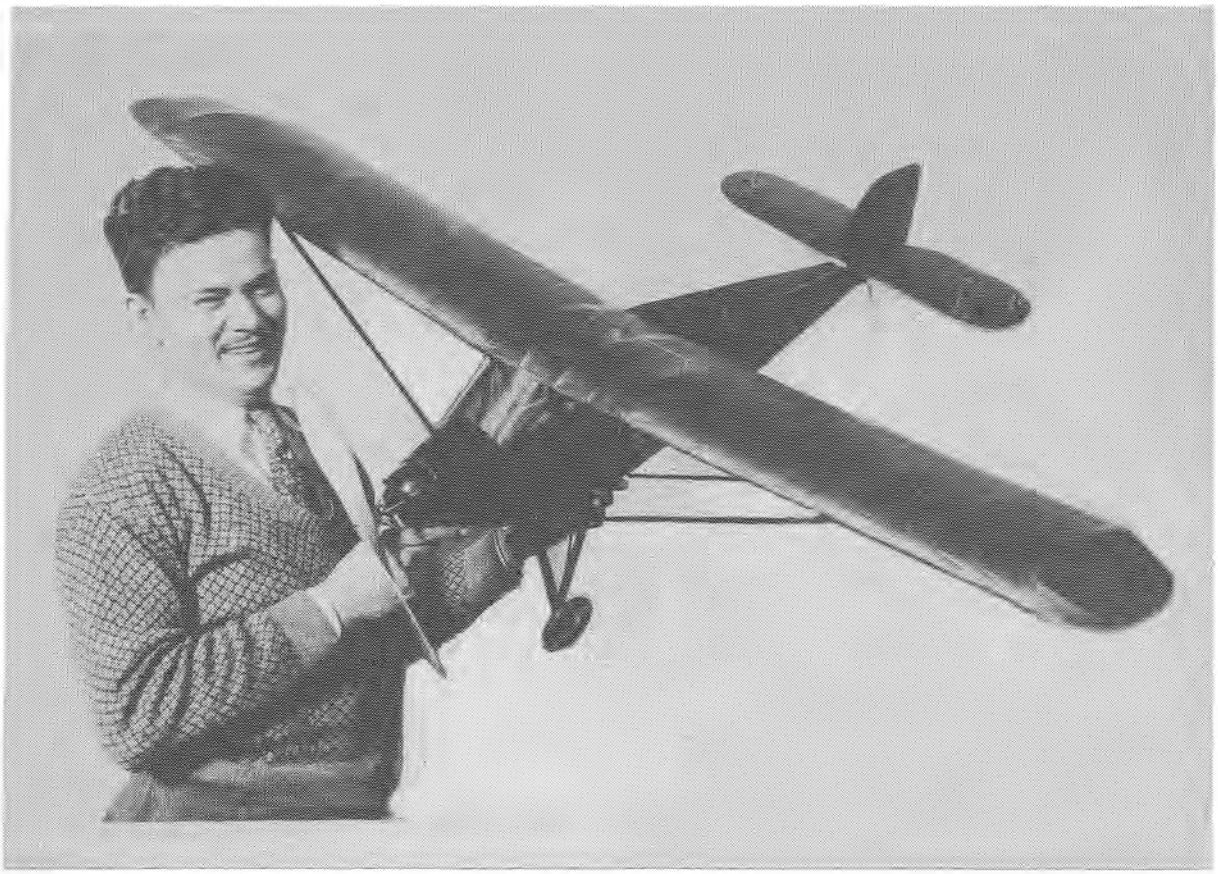
Orlan Corben of sport plane fame enjoyed building model aircraft. It was a natural thing for him to build miniatures of his full size airplanes. He built them both large & small. The one pictured is one of his larger models, a compressed air replica of one of his famous craft, the Corben Ace. Williams Brothers have a plastic model kit of this plane. On their instruction sheet there is a picture of Corben building this COMPRESSED AIR model.

As can be seen the nose of this model sports a Hoosier Whirlwind 3 cylinder radial mounted on a 3" diameter x 24" long seamless air tank.

Corben did a beautiful job blending the front of the tank into the nose of the model. You would smile too if you had completed such a beautiful craft.

A scale COMPRESSED AIR model like this should be an inspiration to modelers wanting a change of pace.

Corben built this model about 1931 or 1932. He painted it the same colors as the full size ship.



COMPRESSED AIR POWERED ARROW-TAUBE MONOPLANE.

No balsa was used in making this unusual Taube model. Original article of about 1920 or a little later describes model construction. "Before attempting construction study drawings carefully." Use scale on drawing or proportional dividers for laying out full size components-a left & right wing half, a rudder & an elevator. Wing spars are 3/16" x 1/4" spruce -straight grained-shaped on top to a streamlined half section.. See rib drawing. Ribs must all have identical curvature from front edge to spar. From spar to trailing edge is straight line. Ribs are made of .018" steel wire. Trailing edge is also .018" diameter wire. Entering edge should be .022" diameter steel wire. Ends of ribs are bent over on each end to match curvature of adjacent edge of wing & wrapped with several turns of fine wire to hold ribs in place for soldering. Length of angle on ends of ribs should be 3/16" to 1/4" long for making a substantial joint when soldered. Do not use spring wire for binding. Soft steel wire .010 or smaller should be used. Tinned wire would make soldering easier. After soldering, clean flux off with warm water. Spruce wing spars are tied & cemented at each rib. Note that each wing tip has wash-out plus a wing tip dihedral. Wire loops bolt wing to tank through cross tubes at "E" & "F".

Rudder & elevator are built up in same manner as wing using wire parts wrapped & soldered in position. Tail wheel wire supports are soldered to under side of wires of elevator. In order to fasten covering material to elevator, a "U" shaped piece of wire which fits closely to tank is used. This "U" shaped piece has a loop at each end which is fastened with a long bolt #2-56 or smaller. This bolt passes through a tube soldered crosswise through tank. Tube is reinforced with a thin washer that is soldered to tank cylinder at each end. When in position, rudder elevator & tail wheel support fit rear of tank closely. Then front bolt secures tail unit in position at "D".

Landing gear is .040 music wire, wire bound & soldered as shown in detail on right lower part of drawing. Developed true lengths of landing gear struts are- "A"-9-3/4" "B"-11" & "C"-10" To these lengths add 1/2" for small loop on upper ends for bolts & 3/16" for angle bends on lower ends used in binding with wire & soldering. These strut lengths may vary with different engines & mounts. Fore & aft skid pieces have curved front ends to protect propeller & act as a shock absorber. Original axle was a heavy 1/8" diameter steel rod. With a lightened model a 3/32" diameter axle is adequate. Axle is 10-1/2" long. Original wheels were 2-1/2" diameter made of rubber. Balsa wheels with brass tube hubs will save considerable weight. Spreader "H" is 5" long with very small loops in each end for bracing wire anchorage beneath wing halves. Upper bracing to wire cabane strut can be light monofilament fishing line.

Original model was covered with light silk. Wing covering was cemented to under side of all wing members. Dope only sufficiently to fill pores of silk. Rig wing halves so as to counteract torque of engine.

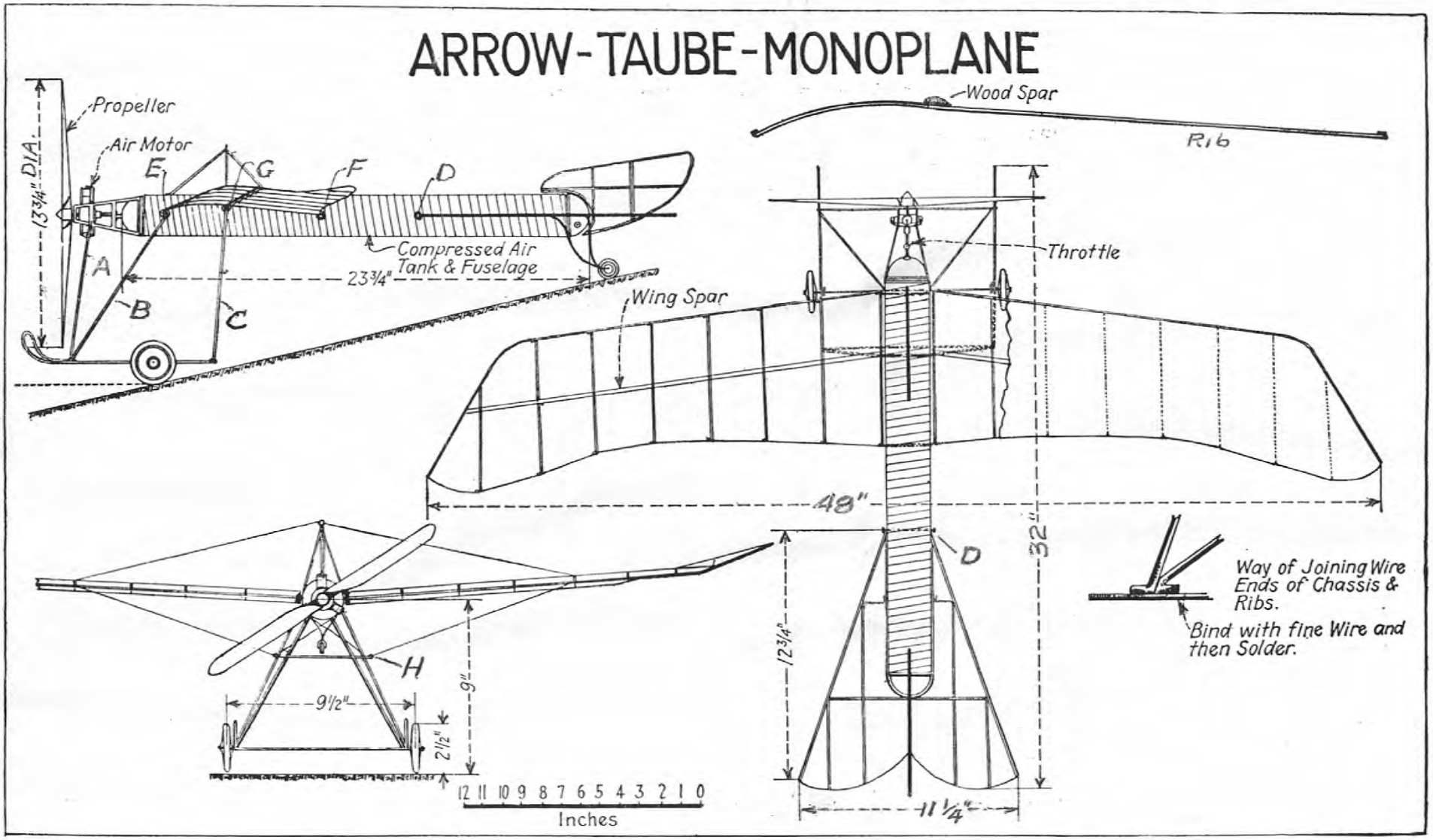
Tank used on original model was 2-3/8" diameter x 23-3/4" long. A more standard size of 3" diameter x 24" long without wire winding will probably weigh less than original tank in addition to providing over 50% more air volume with resulting increase in duration. See section on tanks. Over 30 feet of steel wire on original tank added weight without contributing to strength of tank.

When properly made, this model should withstand flying bumps better than balsa models.

For flying this model, usual procedures should be followed. Adjust to glide as flat as possible without stalling. Then try a hand launch with 50 to 60 pounds per square inch pressure in tank. Launch at gliding speed at a slight upward angle of 5° to 10°. When adjustments are perfect, you are ready to try a flight with full rated pressure in tank-that is if your flying area is large enough! This model should be made to climb rapidly with the first burst of maximum air pressure & then cruise & finally descend in a flat glide.

This machine does not lend itself too well to plastic tanks without a major redesign, but with a bit of ingenuity a balsa fuselage containing a plastic tank could combine with most other components to make a "Fat Taube" instead of an "Arrow Taube"!

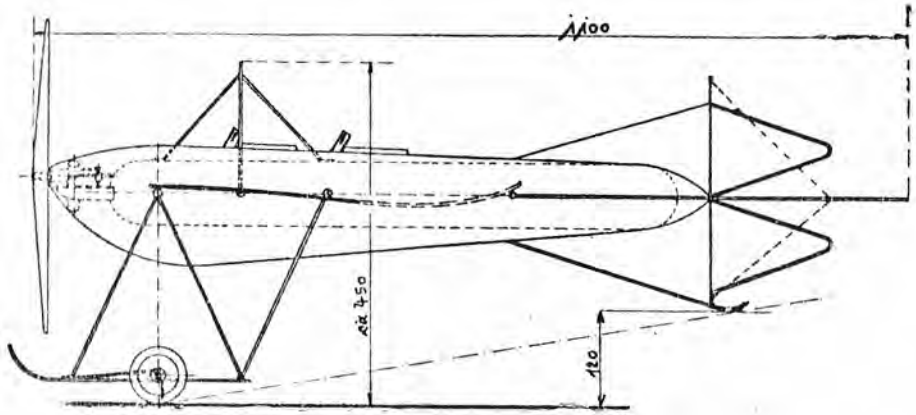
ARROW-TAUBE-MONOPLANE

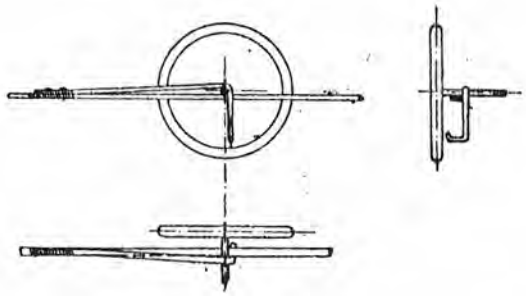


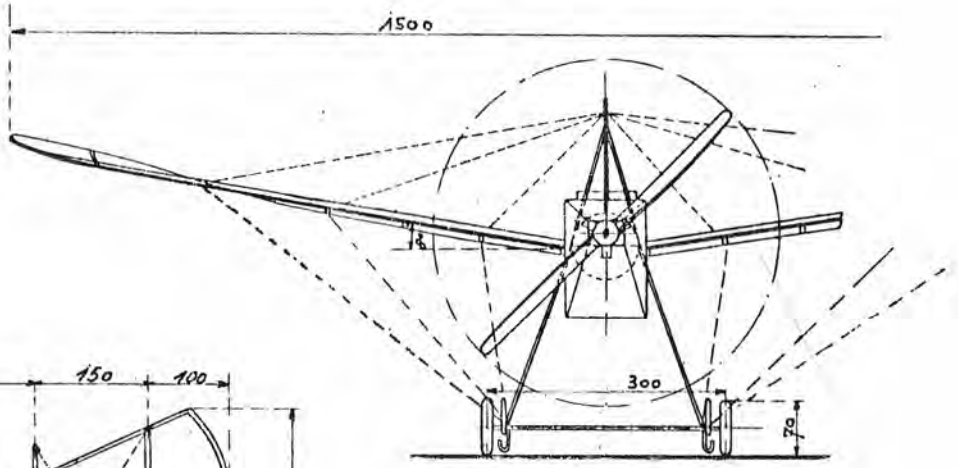
A German COMPRESSED AIR Model.

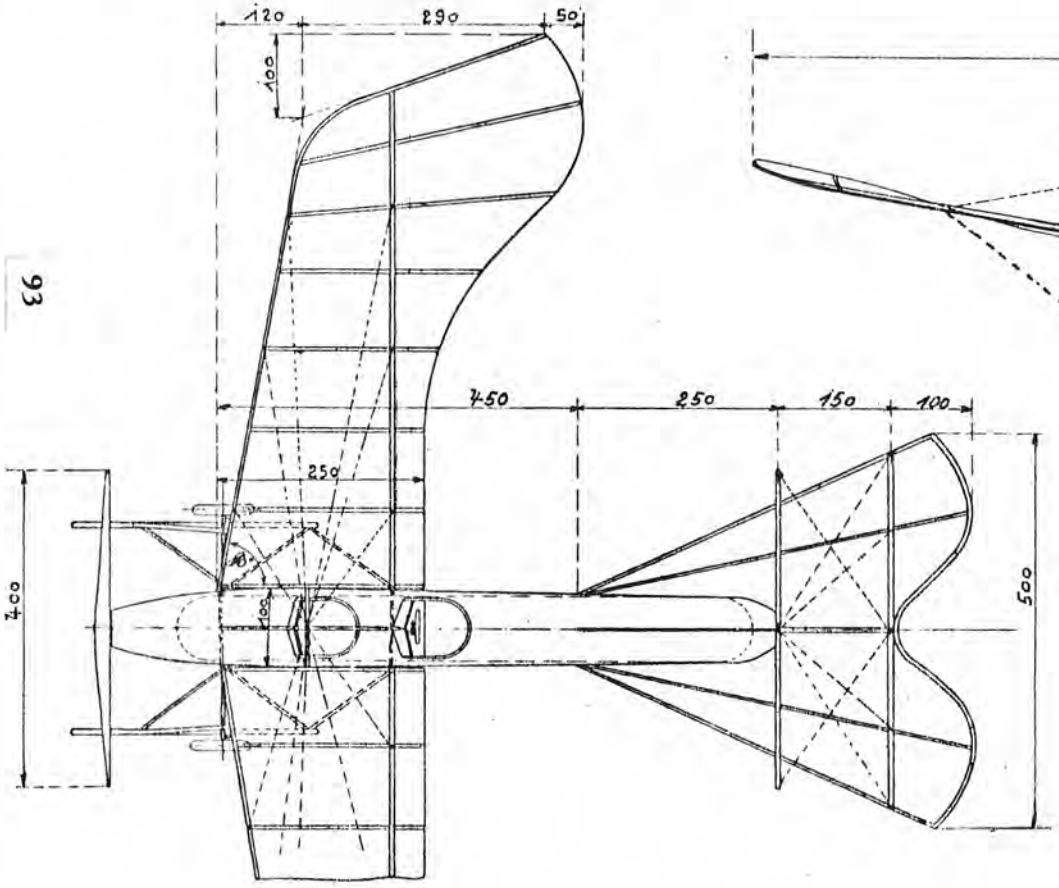
This German model was built around the Bing Autoplan 3 cylinder radial engine & tank. All dimensions are in millimeters. The character "1" is the symbol for the number "1". (Convert millimeters-mm.-to inches by dividing by 25.4)
The wing span is 59".
The wing cord at the center is 9.84".
Overall length from propeller to rear of elevator is 43.31"
Propeller diameter is 15.75".
The wing is securely braced with double wires at 3 span locations on each side above & below. The upper wires are attached to a cabane above the "cockpit". The bottom wires are attached to the landing gear skid behind the wheels.
The wire bracing allows a very light weight structure for the wing. It permits rigging any sort of adjustment required for flying. In addition, wiring may be used for quick assembly & breakdown for transport.
No description accompanied this plan. However we can suggest that the wing is probably constructed with a pine or spruce beam & a spring wire trailing edge. The ribs & landing gear struts could be bamboo.
The wheels are 2-3/4" in diameter & mounted with a unique spring arrangement. The 3 enlarged views show how the wheels are sprung from the front. The wheel travel is restricted by a hook which engages the skid when the wheel is deflected to its maximum travel.
The front edge of the wing is set at an 8° angle to the horizontal. This should provide ample stability laterally.
It is interesting to note that several of the early German aircraft had this same general wing shape & tail contours. The Grohmann & the Taube are similar to this Rumpf. Copy the one which flies seemed to be the scheme.
The fuselage is not detailed as to how it is constructed. It could be made with pine longerons or hard balsa.
The fuselage could be adopted to other sizes of tanks such as the newer light weight plastic tanks or what ever tank & motor that would fly this ship.




1100
ca 450
120




1500
300
70


120
290
50
100
450
250
150
100
250
400
100
500

(DIM. IN MM.)

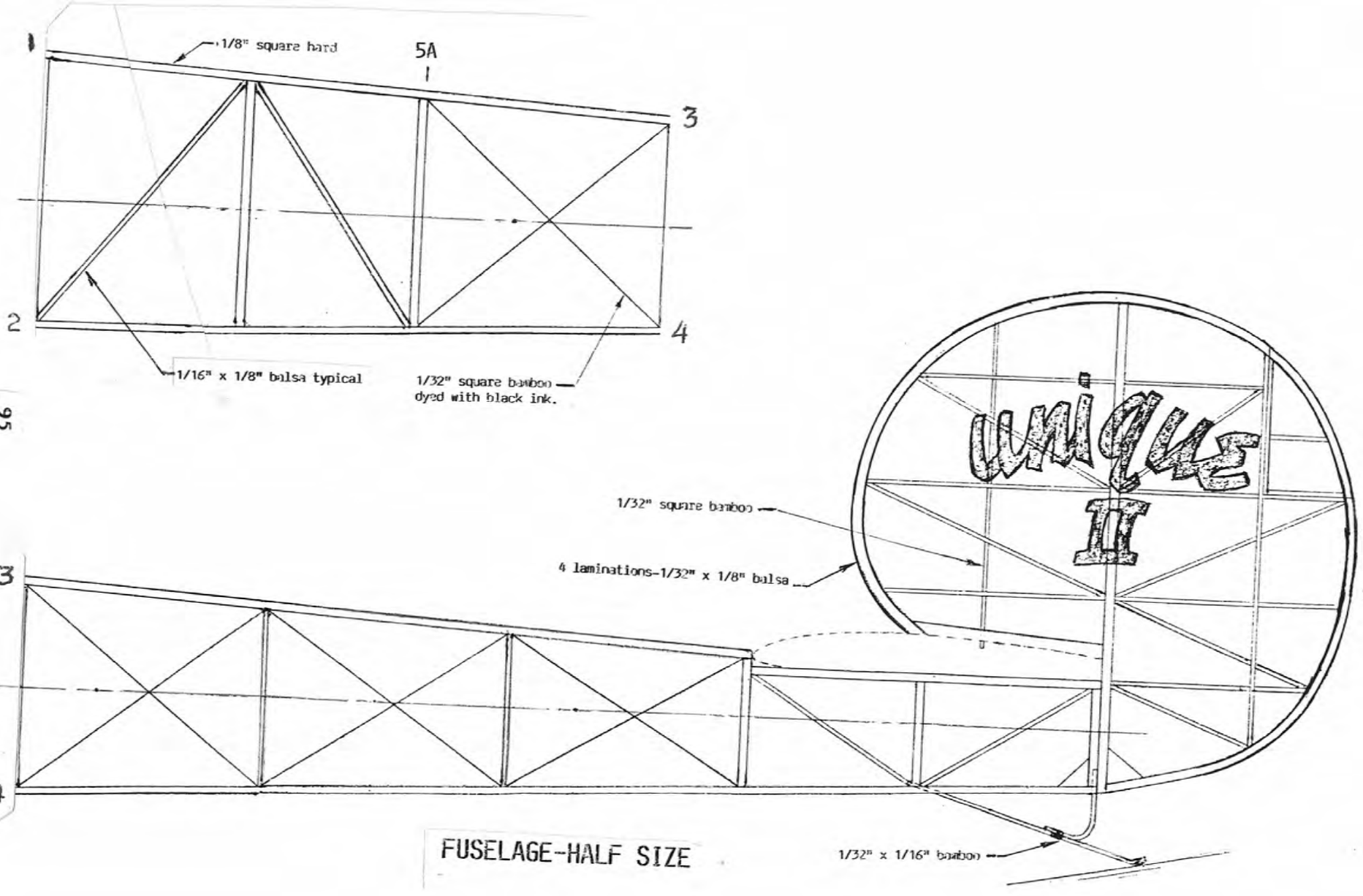
Frank Stotler's "Unique II" COMPRESSED AIR Model.

Here is a most detailed COMPRESSED AIR powered scale model of "Unique II" as constructed & flown by a professional engineer, Frank Stotler. This model has record seldom attained with a COMPRESSED AIR model. Mr. Stotler has made over 65 flights with his Unique II. All have been made with 100 psi. air pressure. Flights have been R.O.G. from a hard surface pavement. Average times have been between 210 & 240 seconds. All flights were timed by stop watch. Several times his ship got into a thermal. He almost lost it on one flight of 15 minutes -23 seconds. Distance flown on this flight was approximately one mile. One other time, a Texas "boomer" thermal whisked his model away. However this time it was found & returned. Another time Frank was flying under low clouds late in afternoon when a "boomer" caught Unique II & it went out of sight & disappeared in clouds overhead & was never returned. This fine model had one of best records of consistent performance of any COMPRESSED AIR model known up to May 1977 when model was lost. Frank's good intention of installing a dethemalizer will have to wait for his next model!

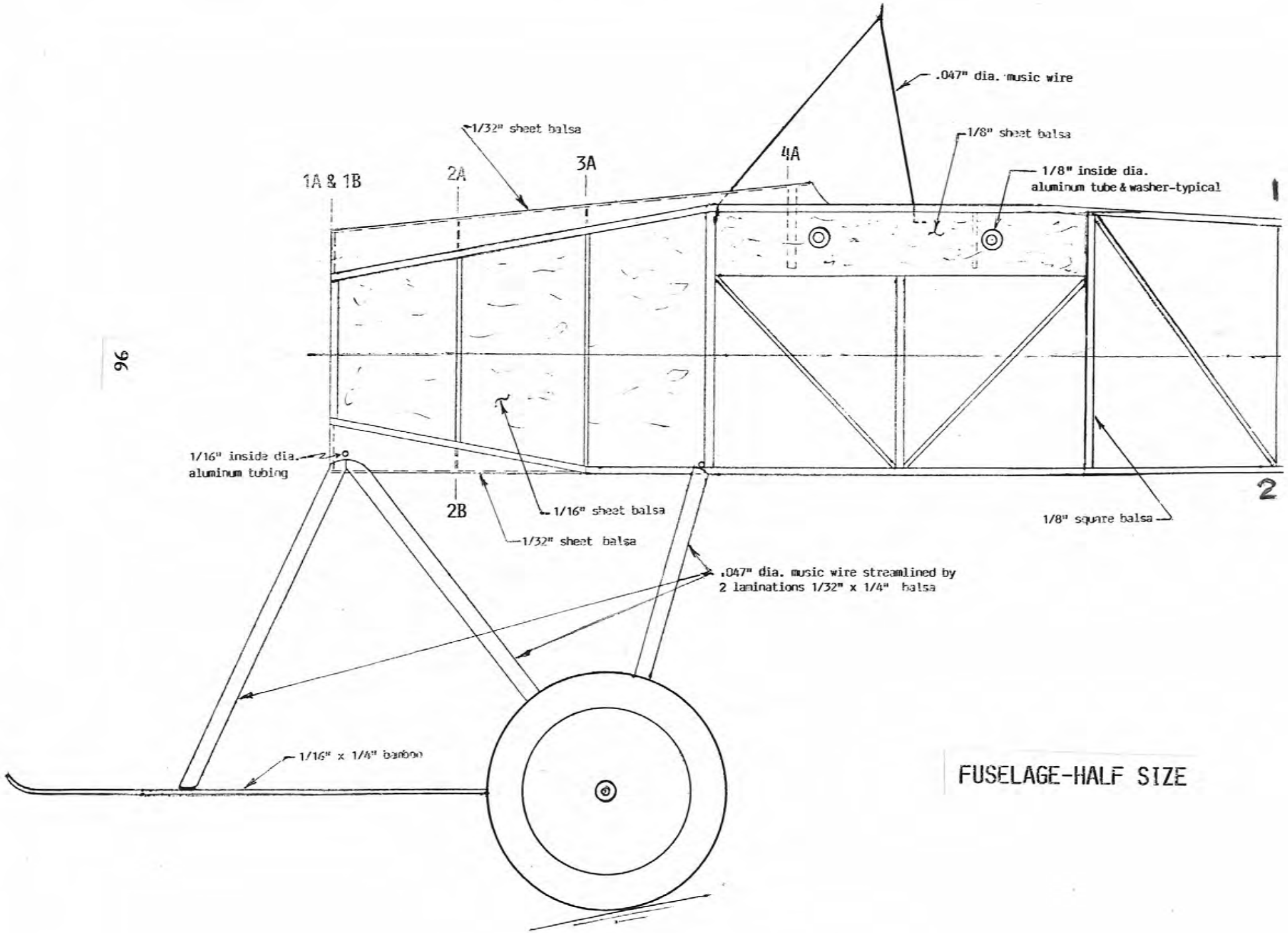
Here are specifications for Mr. Stotler's remarkable performing Unique II model:-

Wing span---------- 60"
Length of each wing panel- 28-1/4"
Wing chord---------- 8-3/4"
Wing area----------494 square inches
Wing airfoil--combination Clark Y-upper & R.A.F. 32 lower
Wing dihedral--each wing tip rigged up 1-1/2"
Fuselage length---------- 43-3/4" overall including rudder.
Horizontal stabilizer span-- 23"
Stabilizer chord---------- 7"
Stabilizer airfoil--Rhode St. Genese 28
Rudder height ---------- 5-3/4"
Rudder length---------- 7-5/16"
Rudder area----------37 square inches
Propeller-----14" diameter-x 16.5" geometric pitch. 10 to 12 pound balsa.
Wheels----------3-1/2" diameter (Williams Brothers used.)
Weight ready to fly-no air pressure in tank-12 ounces = 3.4 oz./sq.ft.
Engine---------- Whirlwind 3 cylinder radial
Tank---------- 3" x 24" seamless brass

Just Imagine a type #13 or #14 plastic tank with 50% more volume & 27% less tank weight in this Stotler Unique II ! (See tank section.) The "wild blue yonder" would soon be full of lost COMPRESSED AIR models.
Stotler used "Hot Stuff" cyanoacrylate for all bonding through-out entire structure. Micro balloons were used where needed for filler.

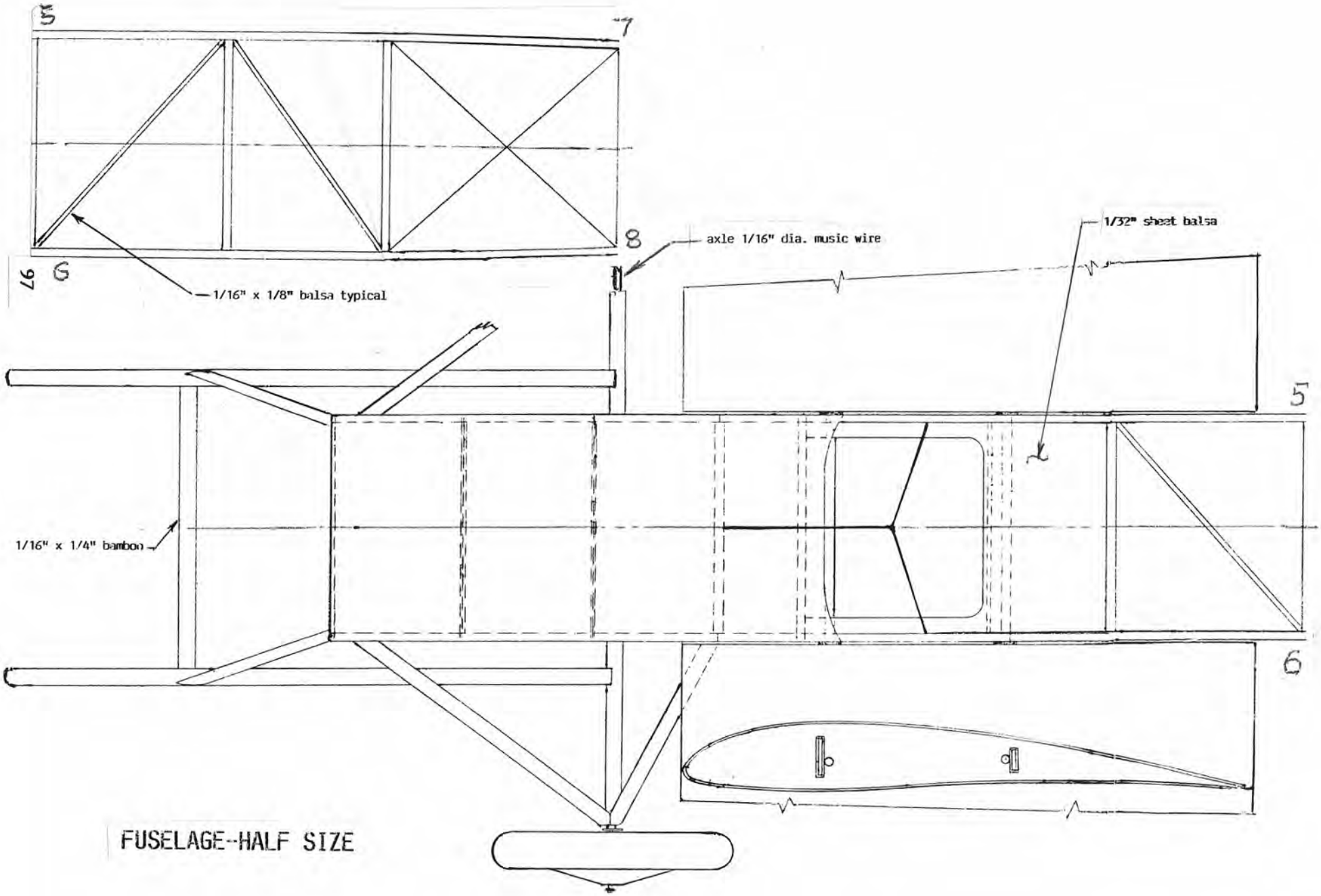


FUSELAGE-HALF SIZE

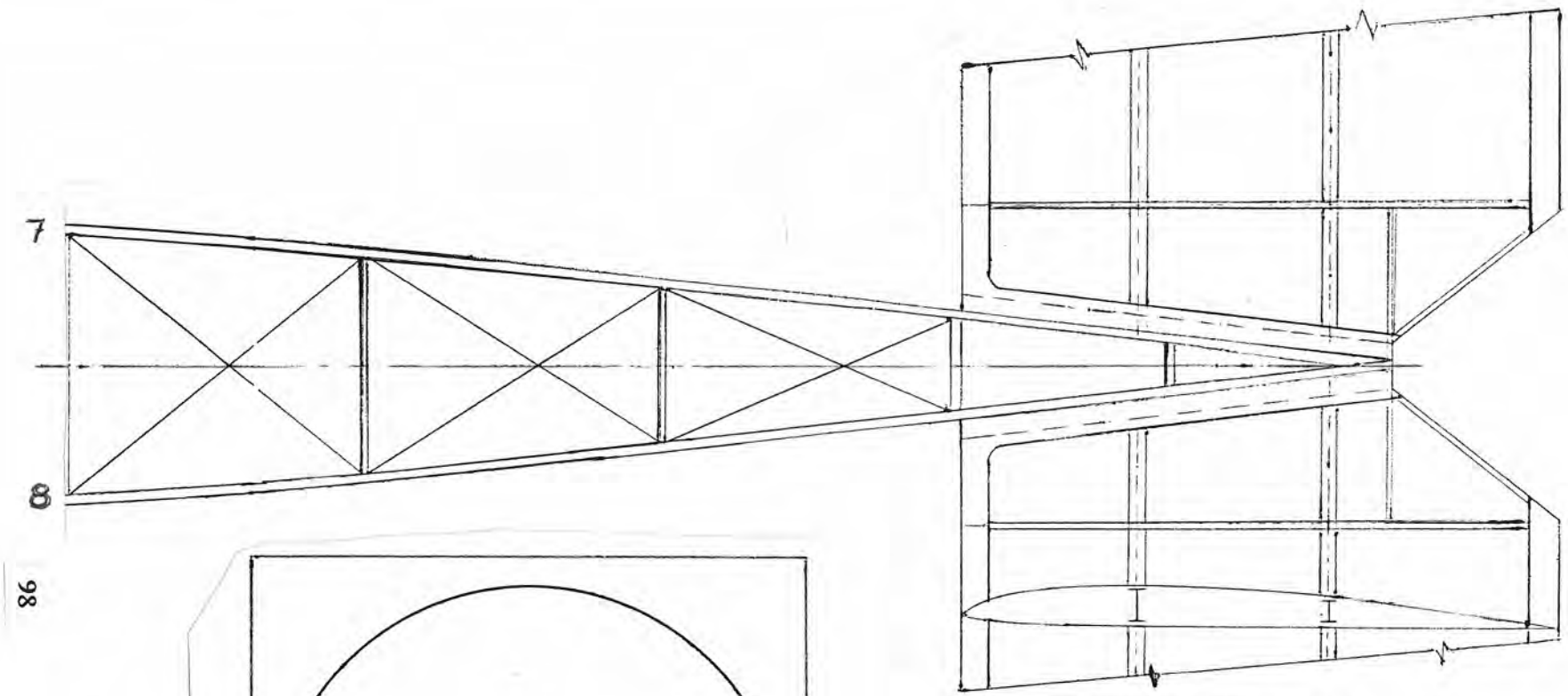


96

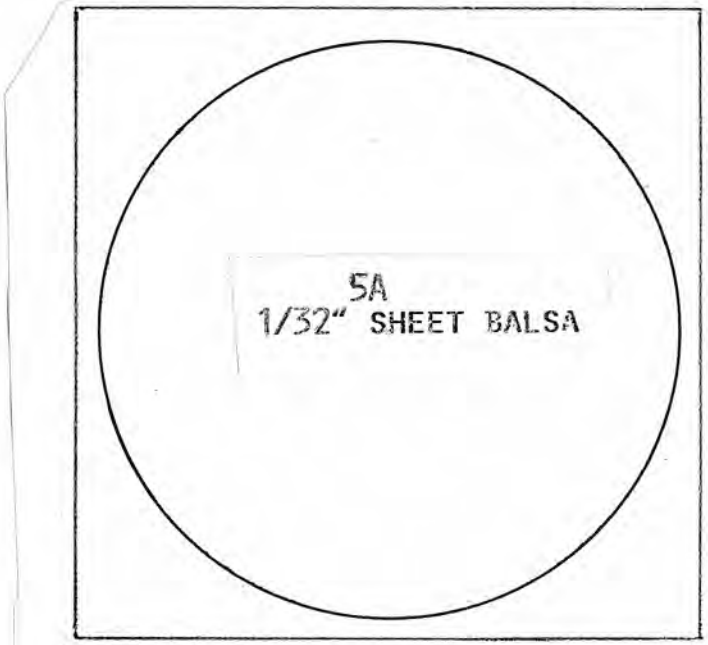
FUSELAGE-HALF SIZE

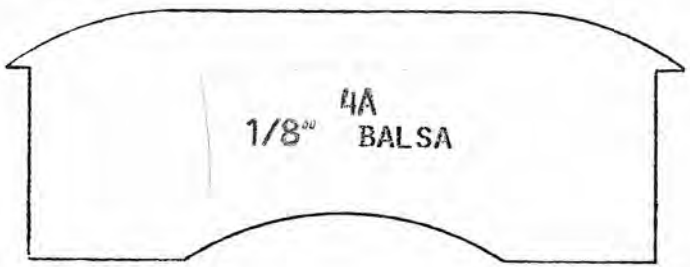


FUSELAGE--HALF SIZE

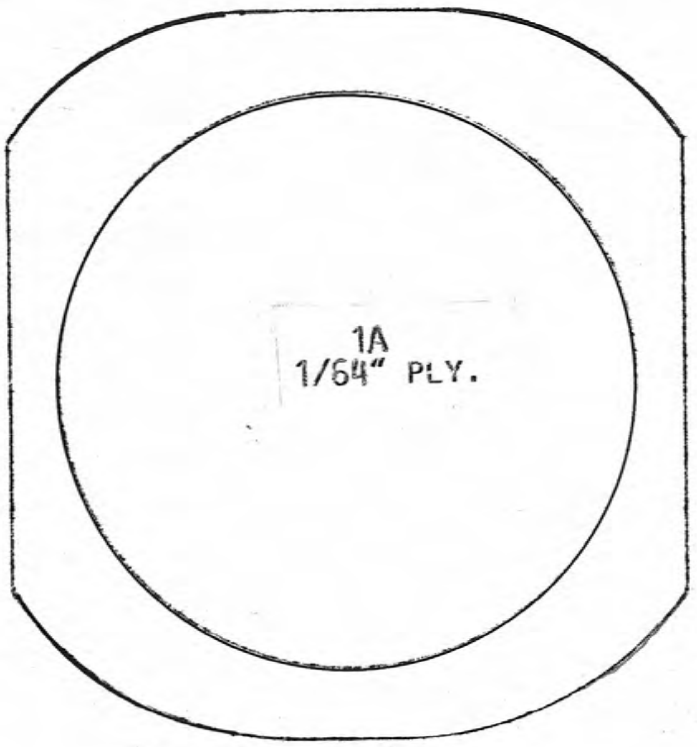


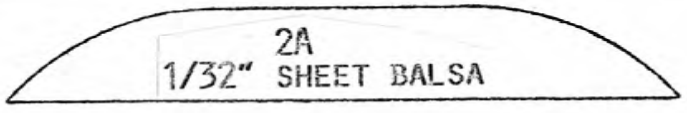
FUSELAGE-HALF SIZE

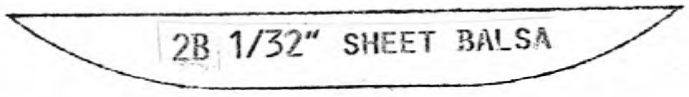


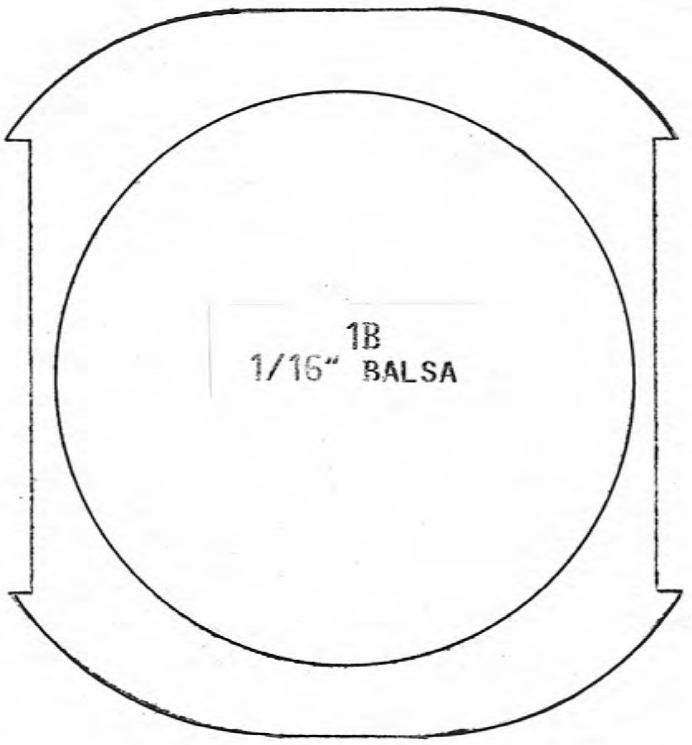


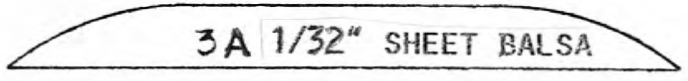
FUSELAGE FORMERS-FULL SIZE



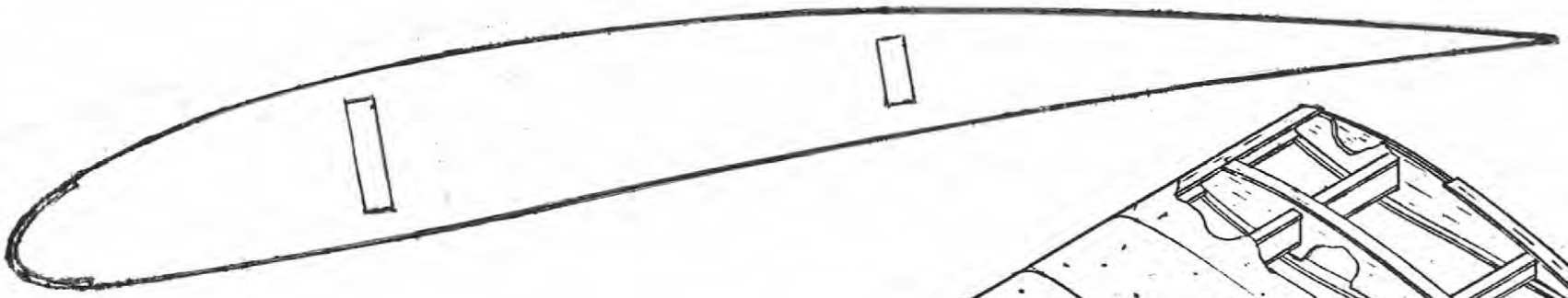








FUSELAGE FORMERS-FULL SIZE



Wing rib-full size-34 total required.
(Note-end ribs are doubled.)

Wing- approximate scale
1" = 3.28"

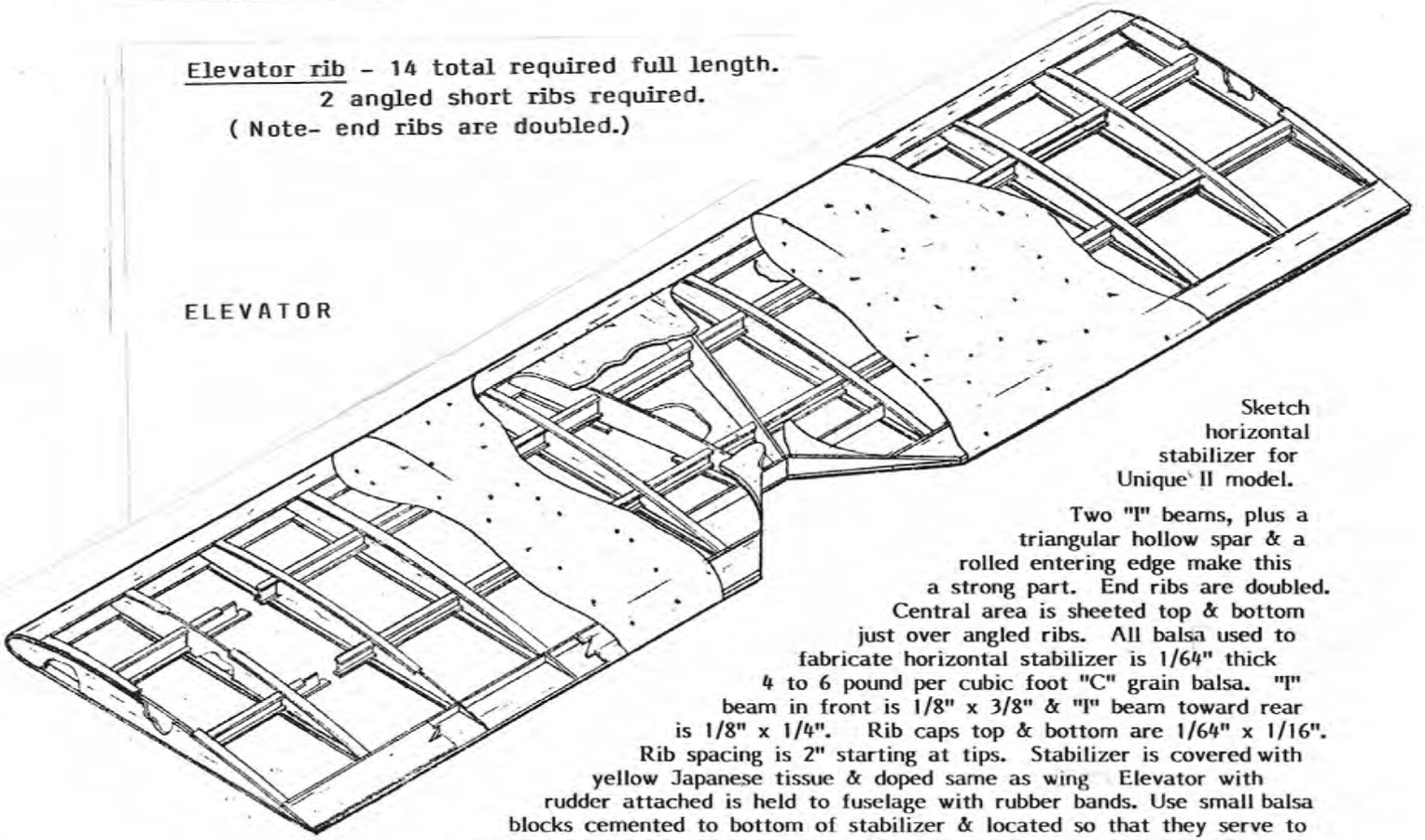
Sketch of
wing -Unique II.

Three hollow spars & a rolled entering edge of balsa make this wing quite strong. Box spars- 5/32" x 5/8" for front & 5/32" x 3/8" for rear & built up triangular hollow rear spar show expertise in construction. End ribs are doubled. Outer 13 ribs-of 15 total - are capped. All of balsa used in wing halves is 1/32" thick 4 to 6 pound per cubic foot "C" grain. Rib caps are 1/8" wide. Cap at outer end rib is offset so that it is flush on the outside end of wing. Inner ends of wing halves have 2 short 1/8" dowels which plug into upper fuselage sides to properly position wing root. Small wire loops for attaching 6 pound monofilament project through cap strips at wing beam locations at 5th rib from wing tip. Wing is covered with yellow Japanese tissue & doped with thinner laced with just enough dope to lay any fibers & shrink tissue to a smooth surface.
Note that 2 inner ribs are sheeted over on both top & bottom of wing with 1/32 balsa.



Elevator rib - 14 total required full length.
2 angled short ribs required.
(Note- end ribs are doubled.)

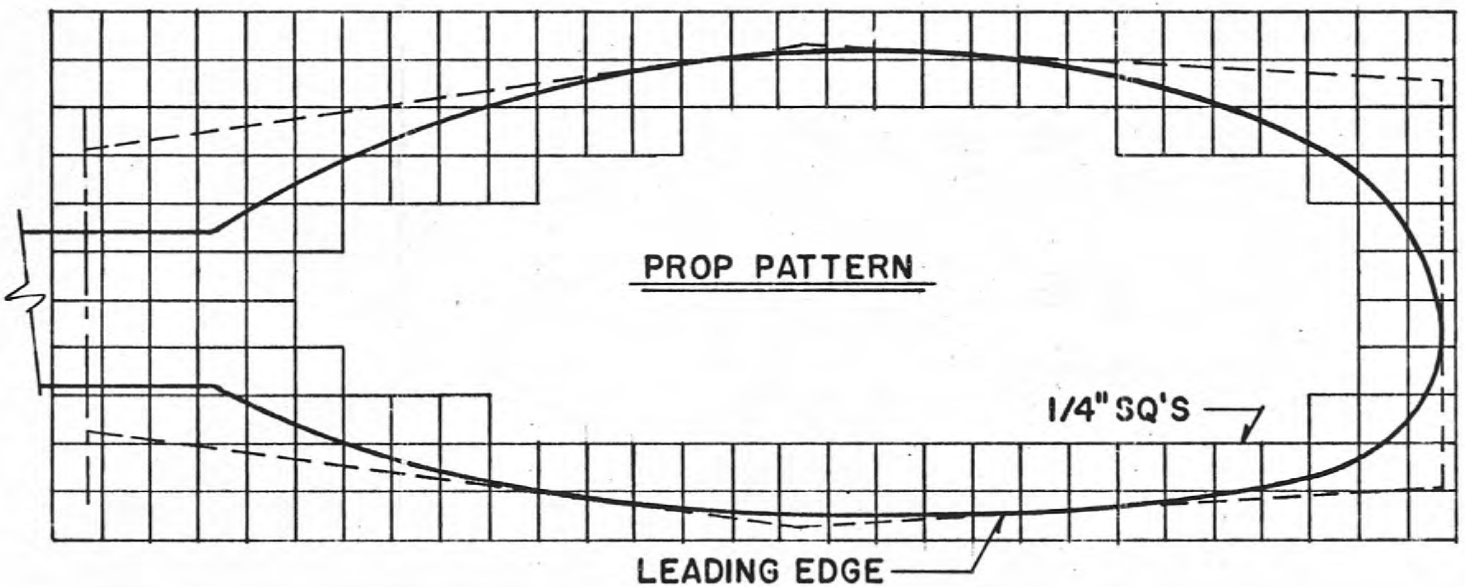
ELEVATOR

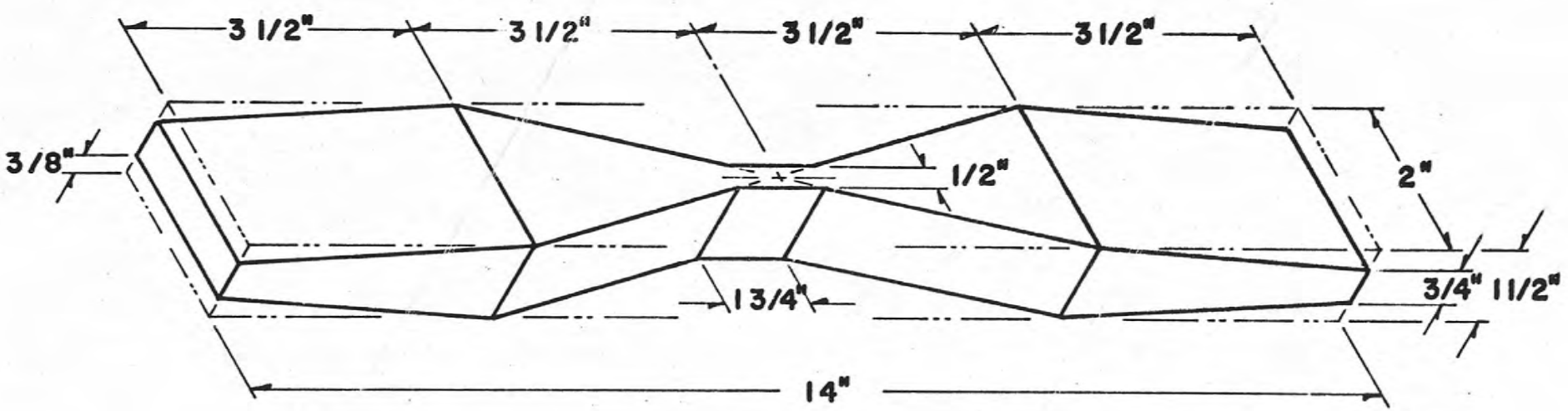


Sketch horizontal stabilizer for Unique II model.

Two "I" beams, plus a triangular hollow spar & a rolled entering edge make this a strong part. End ribs are doubled. Central area is sheeted top & bottom just over angled ribs. All balsa used to fabricate horizontal stabilizer is 1/64" thick 4 to 6 pound per cubic foot "C" grain balsa. "I" beam in front is 1/8" x 3/8" & "I" beam toward rear is 1/8" x 1/4". Rib caps top & bottom are 1/64" x 1/16". Rib spacing is 2" starting at tips. Stabilizer is covered with yellow Japanese tissue & doped same as wing Elevator with rudder attached is held to fuselage with rubber bands. Use small balsa blocks cemented to bottom of stabilizer & located so that they serve to position rudder stabilizer assembly always in same true position on fuselage.

PROPELLER BLADE PATTERN & BLANK DIMENSIONS for STOTLER'S "UNIQUE 2" MODEL





CARL H. FASTJE COMPRESSED AIR MODEL AIRPLANE.

In 1921, Carl Fastje from out in corn country-Dennison Iowa under 5,000 people-provided modelers with a neat COMPRESSED AIR model design. He had no club members to exchange ideas with. Working alone, his model shows considerable ingenuity.

SPECIFICATIONS:-

Wing span----------60"
Wing chord---------- 9"
Wing section----------USA #5
Angle of incidence---------4°
Propeller diameter---------18"
Engine----------twin opposed
Engine bore----------5/8"
Engine stroke----------5/8"
Tank-tapered ----------26" long x 2-3/4" diameter at front & 1-3/4" at rear
Total weight of model-----18.75 ounces

Although tank was rated at 150 psi, Fastje was unable to find a pump which would deliver more than 100 psi. Consequently his flights were only a few hundred feet. Some construction details are worth noting. Wing spars were 1/4" diameter dowels. Entering edge of wing was 3/32" diameter bamboo. Wing ribs were 1/8" thick balsa, a rather early use of balsa! Entering edge was secured to ribs with thread through a small hole drilled 3/8" from front. Scalloped trailing edge was #34 tinned steel wire. Wire was held in small notch in trailing edge with thread & glued similar to entering edge fastening. Rear end of ribs next to body required an angular brace to take tension of wire & doped covering.

Tail surfaces are made similarly to wing. Spars were 5/32" diameter dowels. Ribs were 3/32" thick balsa of streamline section. Corner cross braces are required for same reason as required for wing halves.

Surfaces are covered with silk & doped lightly.

Fuselage longerons are 42" long. See drawing for method of fastening tank to these longerons with aluminum straps & small #2-56 screws & nuts. Tank is clamped at rear of front end cap on tank & at front of rear end cap. Strips used were 1/32" by 1/4" section. Author prefers Fastje's straps over through-rods others use!

Cabane struts for wing wire bracing were 1/8" diameter aluminum rod.

Landing gear axle of 1/8" aluminum rod was supported by streamlined bamboo of 1/8" x 1/4" section.

Wheels are balsa wood well streamlined. A piece of 1/8" inside diameter brass tube formed wheel bearing. Tube was reinforced by washer on each side of wheel.

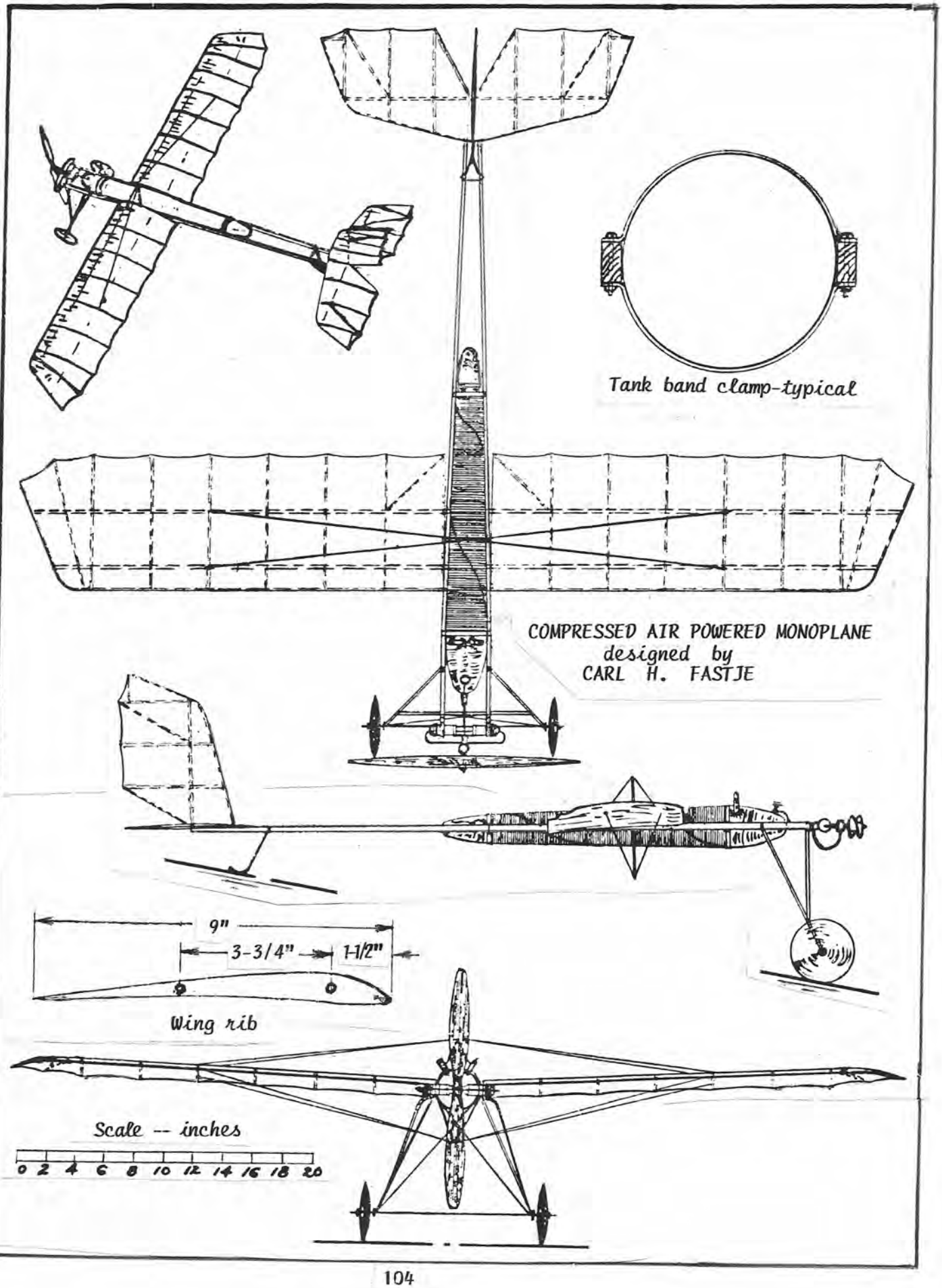
Tail skid was of bamboo 3/16" x 3/32" split part way & spread for attaching to longerons.

Wing bracing wire was .016 brass.

Streamlined tank looks pretty but it was fairly heavy & had relatively small volume. Wing spars were a bit larger than need be. Ribs in wing could be 1/16" rather than 1/8" used by Fastje if small end of all ribs is coated with cement for about one inch. Construction would require a bit of change to adapt light weight plastic tanks of greater volume to this model but results could be surprisingly worth while.

With reduced weight on rest of model including a balsa propeller, landing gear struts could be reduced from 1/8" x 1/4" to 3/32" x 5/32", longerons could be similarly reduced in size or else made of balsa rather than spruce or pine used by Fastje.

So get a good pump & put a dethermalizer on your version of an up-dated Fastje model.


Tank band clamp-typical
COMPRESSED AIR POWERED MONOPLANE
designed by
CARL H. FASTJE
9"
3-3/4"
1-1/2"
Wing rib
Scale -- inches
0 2 4 6 8 10 12 14 16 18 20

"Crusader" COMPRESSED AIR Model.

Original plan for this model by F. A. Lowe was published in a series of 5 issues in "Model Engineer"(England) in 1932. Mr. Lowe's first two articles in the series were a preface to final three construction articles.

Specifications for Crusader:

Wing span ---- 96"
Wing chord ---- 10.5"
Wing area -- 1000 square inches
Wing loading-- 5.9 ounces per square foot
Total weight -- 40 ounces -complete model
Overall length- 54"
Engine-D.A.Pavley 3 cylinder radial
Tank-D.A.Pavley 3" diameter x 24" long
Propeller-D.A.Pavley-18" diameter
Weight power plant-(no air)-16 ounces
Level flight speed-14.5 miles per hour
Initial climb angle-40°
Wing section- F. A. Lowe special
Landing gear-Avro center skid type.
Type-low wing monoplane
Tractor

Mr. Lowe tested his Pavely power plant for maximum initial burst of thrust before beginning construction of his model. Maximum initial burst of thrust measured in ounces multiplied by 4 is limiting maximum total weight in ounces which model can have & make rise off of ground flights with any degree of success. Lighter weight than 4 times thrust would be better. See section on thrust testing. Lowe then built his model Crusader to be within this weight limit.

COMPRESSED AIR models of this time period had been performing too well winning most of events. In order to make other models more competitive with COMPRESSED AIR models various handicaps were placed on COMPRESSED AIR models. One of these handicaps was a requirement that COMPRESSED AIR power plants must be readily removable. Mr. Lowe's model complied with this rule by supporting rear of tank with a skewer rod through a small wire eyelet soldered to rear of tank & two eyelets on adjacent fuselage longerons. Front end of the tank rested on a half circle of fuselage nose & was restricted from motion by a semi circular bail which was slid up over tank end holding tank securely.

Lowe emphasized light weight construction all over with the exception of landing gear. A central Avro type of skid projects forward in order to better protect propeller & engine in case of a bad landing. Skid consists of two laminations or leaves of a spring made from 1/8" x 3/4" ash. Laminations are tapered slightly in width toward each end. Wheels are 4-1/2" diameter cut from 3/16" plywood with cutouts leaving 4 spokes in order to save on weight. Axle is confined to vertical slots permitting of considerable spring action over rough terrain. Lowe states that model takes off of grass with ease with wheels & axles bobbing up & down.

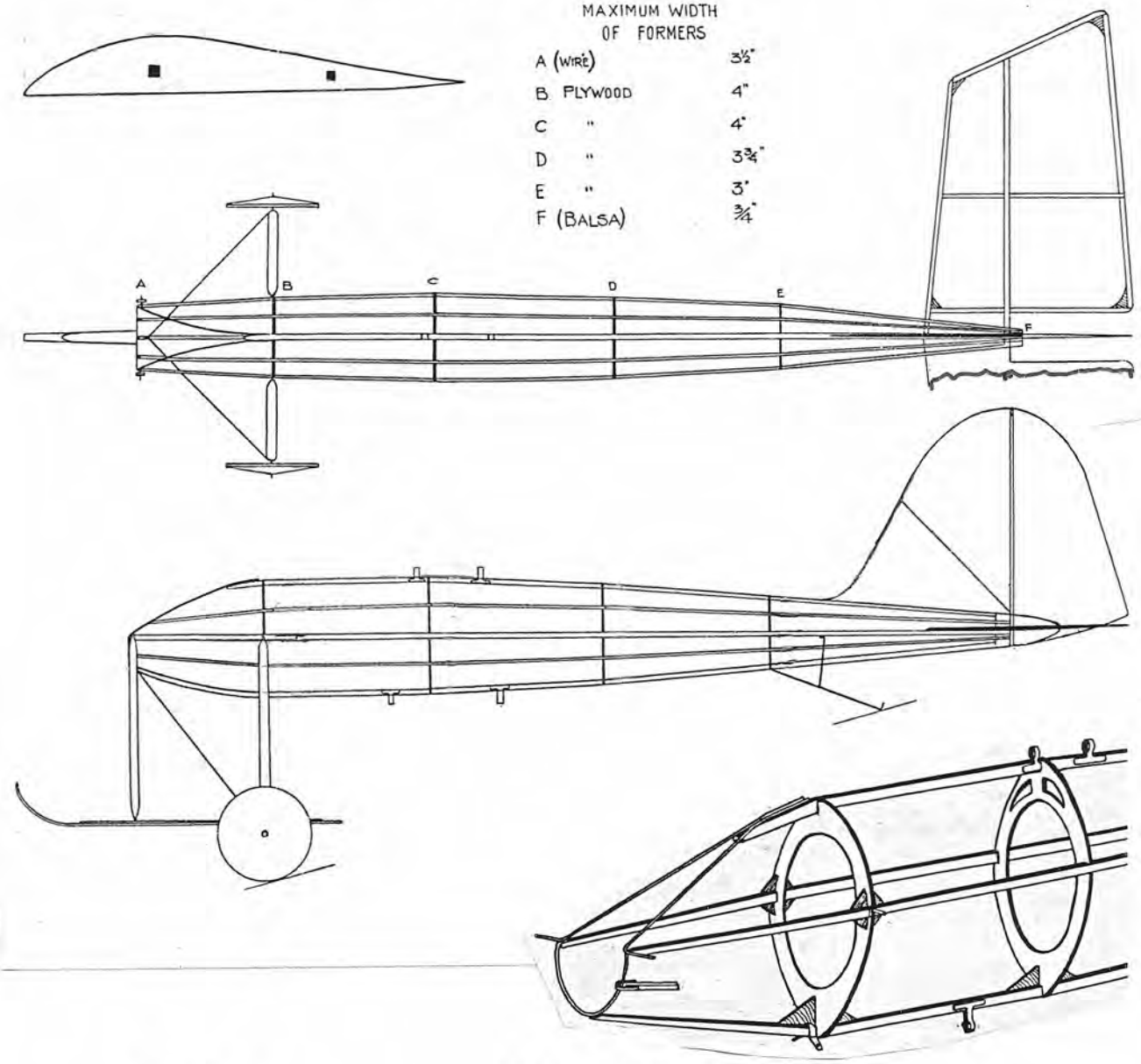
Fuselage is roughly diamond cross section with four 3/32" plywood formers cut out for lightness. Two front formers are braced with gussets at lower longeron. Top & bottom longerons are 3/16" x 3/8" at center & tapered to 3/16" square at ends. Side longerons are 1/8" x 1/4" spruce tapered to rear only to 1/8" x 3/16". Four stringers are 1/8" square spruce. Longerons & stringers converge at rear in notches in a cone of balsa.

Tail skid is .080" diameter music wire bound & cemented to longerons.

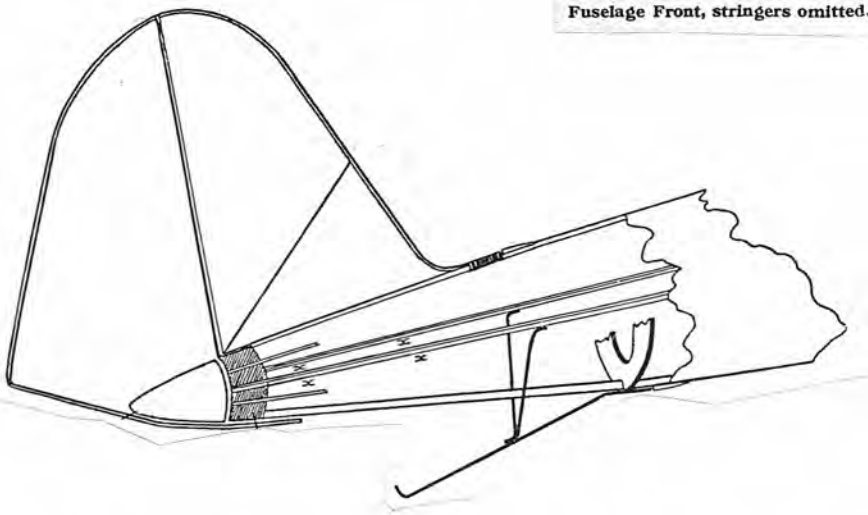
Elevator & rudder would seem at first glance to be a bit on the large side. However the moment arm to the center of lift is quite short in proportion to wing span & this justifies a large tail area. Elevator corners are gussetted for strength with 1/16" plywood. Leading & trailing edges are 1/8" x 1/4" birch rounded on outside edges. Main spar is 1/4" square reduced in thickness toward ends to match tip thickness.. Lowe secures tail to fuselage by binding & cementing. Angle of elevator to thrust line should not exceed 2° negative.

Wing is made in two halves which are joined to bottom longeron with a skewer which engages hinge like loops on longeron & wing halves at spar ends, Ribs are 1/16" with optional cutouts to save weight. Two false ribs are spaced equally between main ribs. Entering edge is 3/16" x 5/16" birch. Trailing edge is 1/8" x 1/2" spruce thinned to a sharp vee at the rear. Front spar is 1/4" square & rear spar is 3/16" square spruce. Lowe made root & tip contours on wing of .048" diameter music wire. 3/16" square drag trussing is glued & gusset reinforced at each joint. Wing roots have gussets to stiffen wing beams.

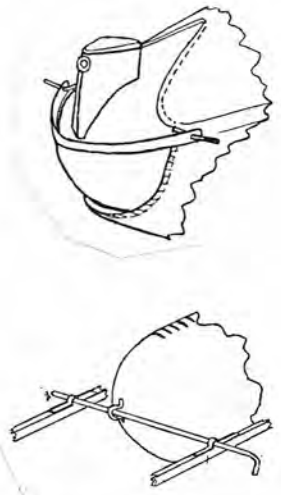
Crusader Details



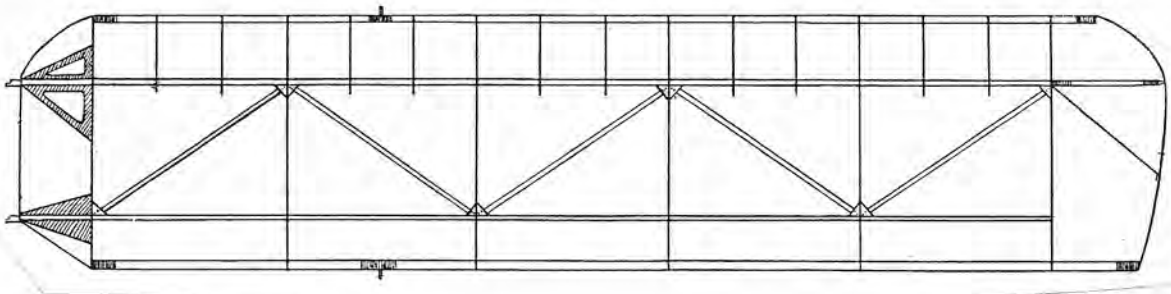
Fuselage Front, stringers omitted.



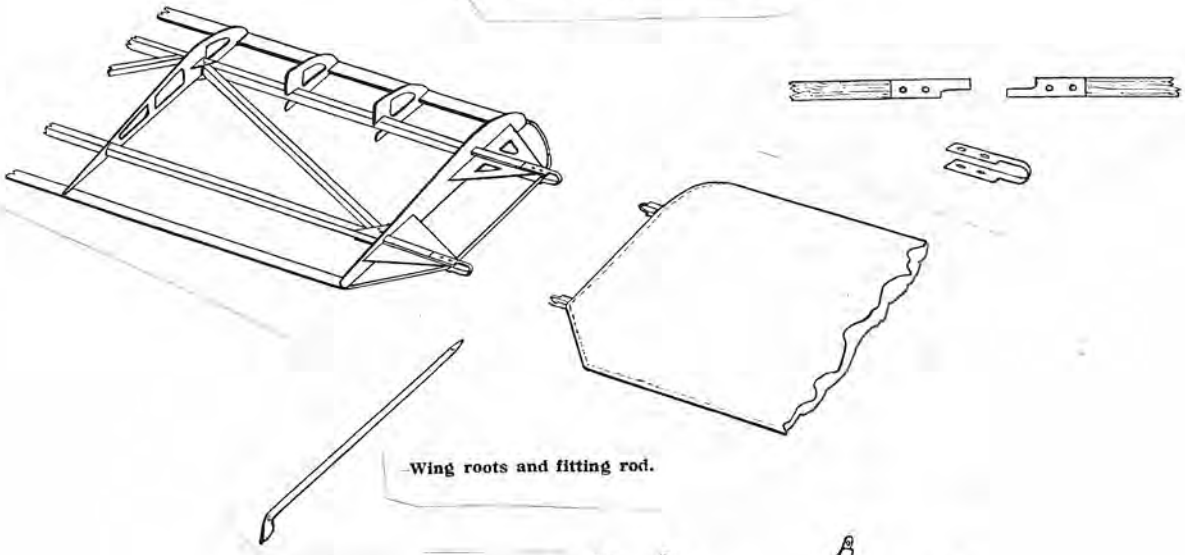
Rear Construction of Fuselage and Fin.



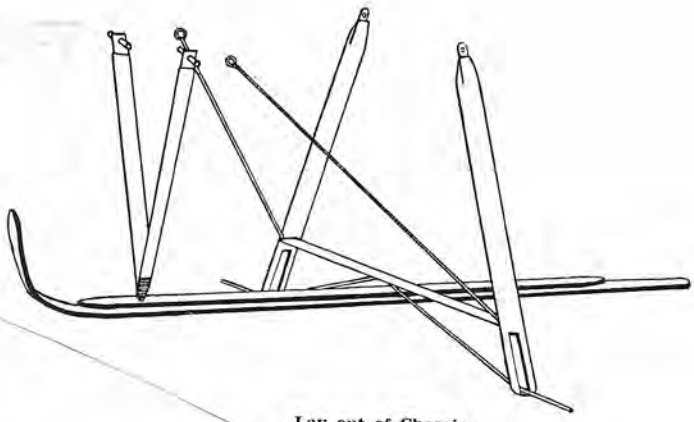
Method of fixing container.



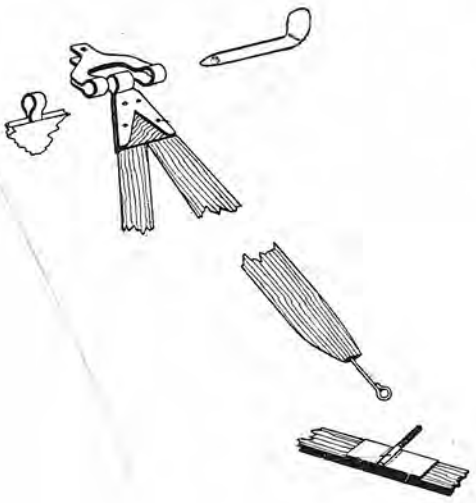
Details of right hand semi-span.



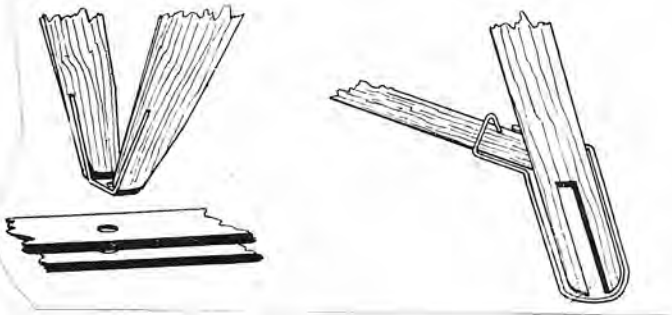
Wing roots and fitting rod.



Lay out of Chassis.

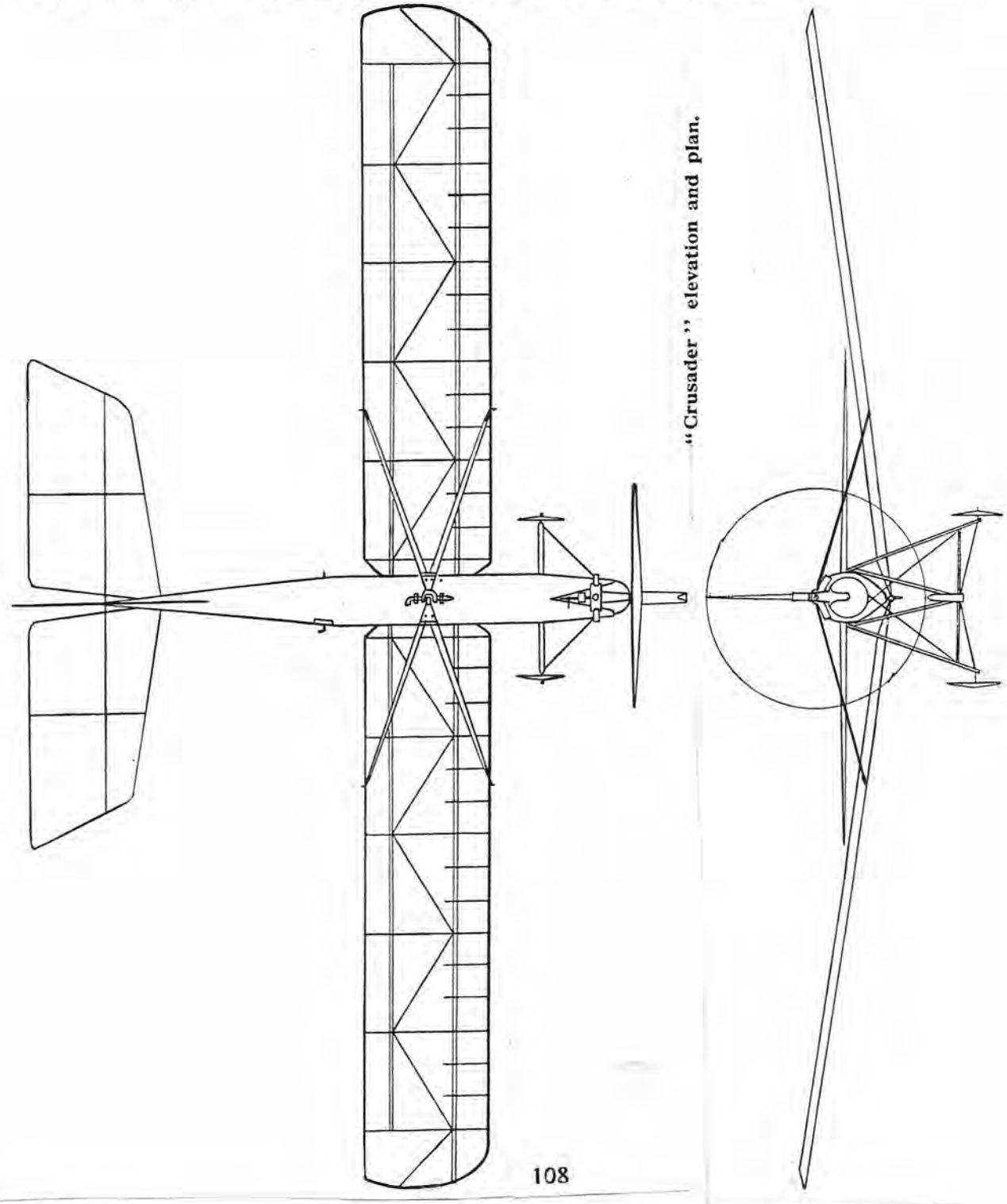


Wing struts and fittings.



Details of front strut fittings to skid; and axle slot.

Wing is braced with 4 streamlined birch compression struts 1/2" wide. These struts are joined at one place to the top fuselage longeron with a pin type fastener through loops on fuselage & struts. Lower end of struts have a heavy wire loop which is slipped over a screw. Screw is soldered to a plate mounted on wing edges. Screw is intended to take all normal loads but to break loose from plate in case of a bad landing thus hopefully reducing possible damage.
All covering is silk with light doping using clear to show up silk.
Model flies well with wing set at 4° incidence. Rudder is set against torque for best results.
Using balsa construction, modern type cements & plastic air tanks this model could be made half of original weight with resulting improvement in performance. With less weight, one rib bay on each side could be omitted. The elevator could be reduced in area proportionately & get much improved performance. Fuselage section would have to be adjusted to what ever size of tank was used.



"Crusader" elevation and plan.

Joseph Stephan Ott Expansion Engine Model Aircraft.

"Joe" Ott died on June 25th 1986. His model aviation accomplishments will live for years to come. Although Mr. Ott had many varieties of model aircraft built, published, & kitted, our interest in his work is his expansion engine equipped model aircraft.

Ott experimented with flash boiler steam engines but commercial production was never undertaken.

Ott's first power plant for model airplanes was a COMPRESSED AIR unit in 1928. A Model Aircraft Division of the Amalgamated Sales & Service of Chicago Illinois was formed to manufacture & market this equipment. The term "Featherweight" was applied to these products This term aptly describes the items. The light weight frame arms & connecting rods were further lightened by long lightening slits. Pistons, connecting rods & pivots as well as the crankshaft were aluminum. The cylinders were made of thin-wall brass with thin cylinder heads soldered in place. The bore was .50" & the stroke was .625". 1,2,3,4,5 & 6 cylinder engines have been made. However 99% of the engines & knocked down kits sold were the 3 cylinder version. I have seen pictures of the other number of cylinder engines, but I have never seen any at swap meets or "Collectos". I made copies of the odd sizes for "Windmill" John Brown's COMPRESSED AIR engine collection. Only one frame die was made which stamped the three cylinder frame. For six cylinder size, two of these three cylinder frames were superimposed with the arms spaced at 60°. For the other numbers of cylinders, single arms were cut & soldered at 180° for the twin, 90° for the 4, & 72° for the 5 cylinder varieties. Tanks were made of sheet shim brass with spun brass caps soldered in place. Ready made tanks were all wound with wire & chromium plated to a dull silver finish. Both straight & tapered tanks were available. Standard lengths were 24" & 36". Straight tanks were either 3" or 4" in diameter. Tapered tanks were either 4" to 3" or 3" to 2".

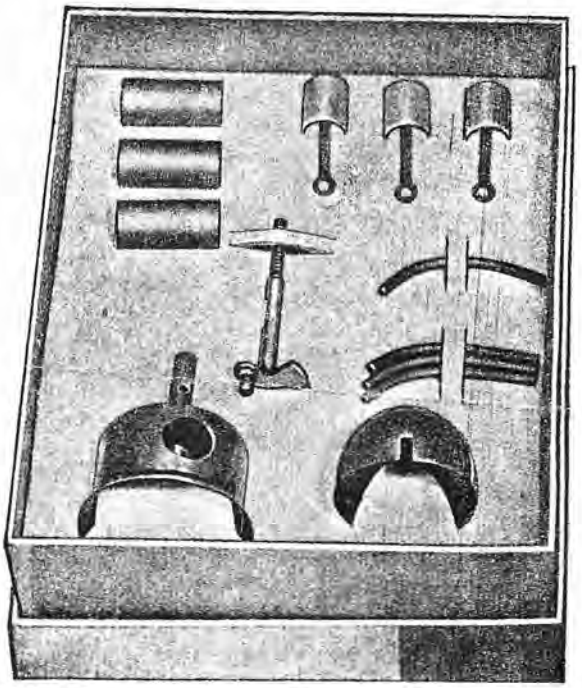
A more detailed look at this first production engine will show its features. The large 6-1/4" overall diameter gives the engines a large, ungainly appearance. Long air feed pipes to the cylinders wasted the volume of air in the pipes each revolution. The long, thin connecting rods with the long slots were too weak & often buckled & blew the piston out of the cylinder when sufficient pressure was applied to try & fly a model. The piston diameters were as die drawn. Commercial tolerances of the cylinders & crankshaft with the valve bearing made fits quite variable. The result was that the engines could run "like crazy" with no load but the limited air supply in the tanks did not last very long. Lapping fits were not possible because the parts were always a wee bit too loose to start with.

Problems with Amalgamated caused Ott to shift his operation in 1929 to the Norlipp Company, makers of an ash catching cigarette holder. Here Ott made several changes in the products. Thinner brass cylinders with the cylinder head integral were bought from a fabricator of metal lip stick cases. This saved making & soldering of the cylinder heads in place. The cylinders were slightly shorter so Ott reduced the engine stroke to .50". This shows up on the crank throws where the pin hole is no longer on the center of the end radius but now closer to the center line of engine. Another apparently great idea for tanks was found. Extra thin-.0045'-wall brass tubing was obtained from the Fulton Sylphon Company, fabricators of industrial controls. They extruded this exotic seamless tubing with a huge expensive special press. The 3" diameter size was just right for the air tanks & saved a lot of labor. These tubes were ordered in modest lots as required.

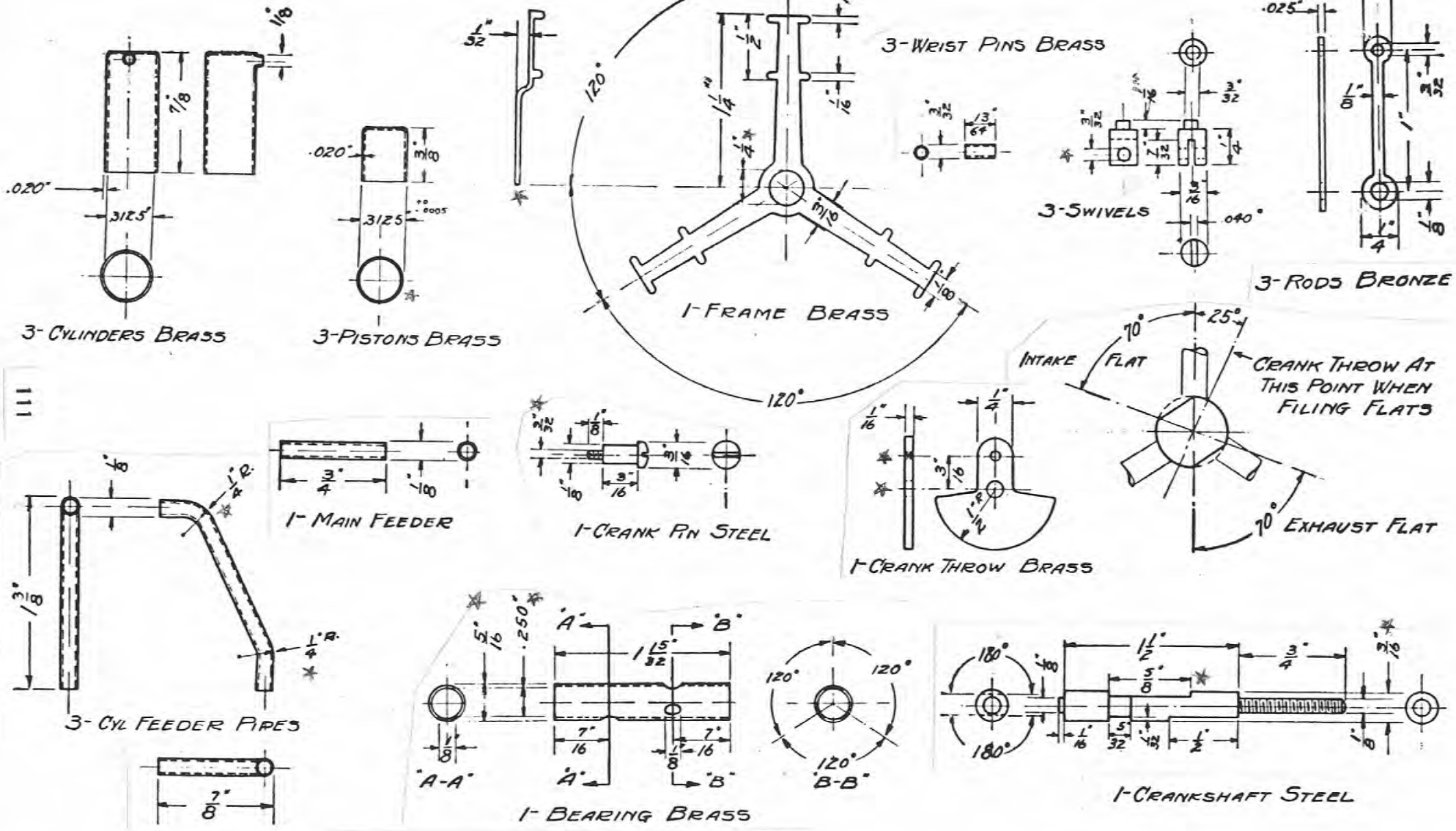
Things did not last too long at the Norlipp Company either. First, there was that "other" stock market crash which reduced sales considerably. Then the Fulton Sylphon Company found a "better way". They scrapped their huge tubing extrusion press & made cups for their bellows fabrication on a simple draw press. When the supply of seamless tubes on hand was used, Ott had to go back to the more costly soldered longitudinal seam tank construction. These unfortunate events reduced the sales of COMPRESSED AIR items to an unprofitable level.

Mr. Ott realized that the COMPRESSED AIR engines needed updating but it had to be done most economically while he sought another connection.

While operating from his basement, a common procedure in those depression days, Joe tried several other revisions in his compressed air engines using surplus parts from obsolete engines where ever these parts could be made to fit.
One COMPRESSED AIR engine "design" drawing in his book "Model Airplanes Building & Flying" was not checked for accuracy & completeness, as examining the print shows at least 13 defects. The 3/16" diameter shaft to fit a 1/4" bearing without air leakage, no rivet hole in the piston, missing hole location dimension on the piston rivet & other similar problems will require a review of the drawing before starting to work! With errors & omissions corrected, the engine should function satisfactorily.



Another engine design was concocted & produced & sold both assembled & as a kit of parts. It was an attractive engine with a two piece spun crankcase. This engine is almost an exact copy of the German made Pause radial 3 cylinder brass engine in external appearance. The picture on the left shows the kit with all of the parts secured neatly on a cardboard platform in a 2" x 5-1/2" x 7" box which bore a $2.00 price tag.
Besides his book, Ott placed model aviation articles in a number of magazines. One of these articles was the plan for a Fokker Super Universal COMPRESSED AIR monoplane, the plan of which is reproduced. This plan drawing was made in November 1928 by Carl Rosmanith, a high school boy. The Ott 3 cylinder radial engine with the long slender connecting rods is shown with an odd length-40"- of tapered tank 2-1/2" diameter to 3" diameter. However, a 30" standard length was called out in the bill of material, & this is the correct length of tank which should have been shown on the drawing. I have marked this 30" length on the drawing. You would need to correct Rosmanith's drawing error by putting the rear tank support hole in the bulkhead #6 & eliminate the sheet balsa & use sticks for the #8 section and odd numbered sections. The 30" tank is necessary to provide proper balance.
The 75" wingspan ship sported 6" diameter wheels. The wingbeam stub spars fitted into aluminum sockets in the center section. Short projecting wire hooks were used with rubber bands to retain the wings securely in place. The main wing beam was pine-3/32" x 1/2" in section. The smaller beams were pine-3/32" x 1/4". The entering edge was 3/16" square pine with the one edge rounded to blend with the airfoil section. Bamboo was employed for the landing gear struts. A wide choice was given for the wing tips-reed, spring wire, aluminum or bamboo. The rudder & elevator were made of 1/8" thick sheet balsa cut out as shown & covered with tissue. The overall length of the fuselage was about 54". After the wing is located for proper balance, a plastic windshield may be fitted.
The plan & description of a unique COMPRESSED AIR biplane by Ott is included in this book. Two large monoplane COMPRESSED AIR models were published by Ott. The one shown on the Ott Products page is similar to the ship which Jack Humphries built using 3 of the 122 cubic inch plastic air tanks. Another was published in a popular shop magazine. See page 117 for plan.
The early Pause engine-before 1920-is shown next to the 1930 Ott enclosed case engine. The only noticeable difference is the lightening holes in the Pause crankcase.
The small picture is of the biplane, plans for which are in this section.



(Not to scale.)

FEATHERWEIGHT AIR MOTOR

Detailed Motor Parts

(✱ Drawing defects.)

Joseph Ott's COMPRESSED AIR Biplane Model.

This model built in 1932 is of rather unorthodox design. It has a skid for a landing gear though a wheel type gear could be readily devised. A longer lower wing than upper wing is seldom seen. Mr. Ott stated that with elevator & rudder assembly removed, balance of model could be readily passed through a car door. Transport does become a problem of larger models. To fly them, they must be transported to flying site.

Area of two wings combined is 1037 square inches. Weight without power plant was 6-1/4 ounces. With power plant and no pressure in tank, total weight was 16 ounces. Wing loading is a small 2.22 ounce per square foot. Depending upon size of tank & pressure, an additional air weight must be allowed for. Also air weight can change center of gravity if center of air volume is at any distance from center of gravity of model. Air weight can be as much as .5 ounce or more. In some cases, modelers have used this shift of C.G. to advantage. For example, if model climbs satisfactorily under full pressure, though slightly over elevated, model with center of air volume BEHIND center of gravity will gradually level off for a good cruise as air weight behind C.G. is gradually reduced.

Two longerons of hard balsa 5/32"x 1/2" x 40" are separated by curved cross pieces of balsa at front & joined at rear. Curve in cross pieces should fit radius of tank used. Tank assembly may be moved fore & aft to secure a flat glide. Tape is used to hold tank in proper position. However rubber bands may be used to hold tank for trial glides. Ott shows a streamlined structure behind air tank. This fairing tapers from a circular section behind tank to a vertical knife edge at end of fuselage longerons.

Rudder & elevator assembly is mounted on top of fairing. Rudder & elevator are constructed of balsa with exception of curved pieces. Curved pieces are all alike & made of bamboo. If you do not know how to bend bamboo, balsa may be used. Rudder is braced on each side to stabilizer & stabilizer is braced to fuselage main longerons. Ott used #2-56 bolts to hold tail assembly yet allow it to be removed readily for transport.

Wing ribs are all alike except for nose ribs which are shorter. There are 26 full length ribs & 26 nose ribs made of 1/16" thick balsa. Four tip nose ribs are a bit shorter than others.

All four "N" struts between wings are identical. Struts are made of 1/8" x 3/8" hard balsa streamlined & assembled to identical shape.

Wing tip skids are bamboo & are of sufficient length to prevent wing tips contacting ground upon landing. Skids are attached to same ribs struts are fastened to.

Wings are mounted to fuselage so that entering edge is 5/16" higher than trailing edge. Ott found that covering of wings was best accomplished AFTER wings & fuselage were aligned & securely cemented. Japanese tissue was used for covering. of all surfaces. Ott used red & white tissues sprayed with water to shrink taut, however, structural skeleton is strong enough to allow use of a light dope.

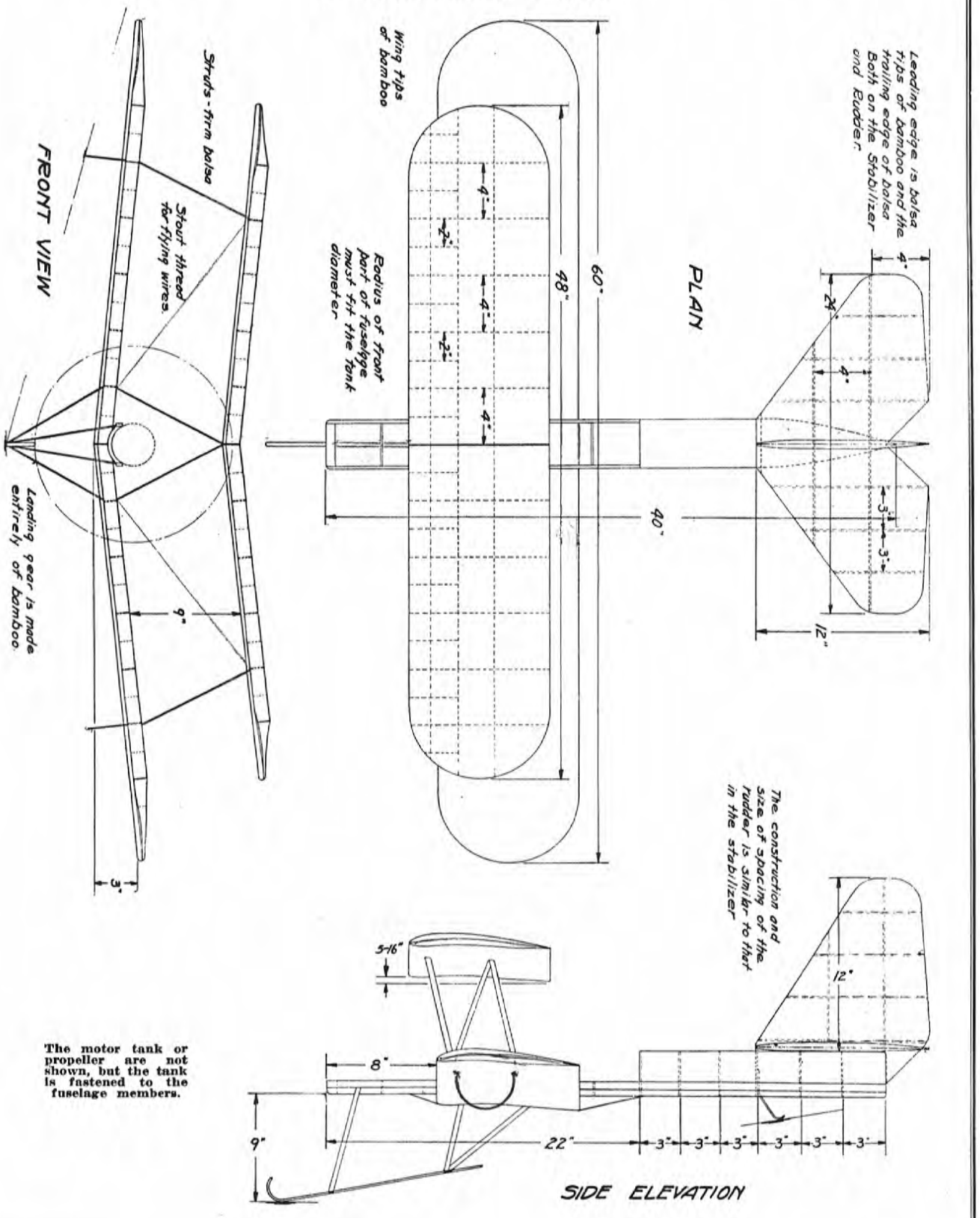
Space between inboard struts permits use of any powerplant with a tank up to 4-1/2" in diameter. Tank streamline fairing requires that it be made to fit size of tank used.

Due to size of this model, power plant should be fitted with a propeller which will provide ample thrust. Power plant should weigh no more than 8 ounces. A plastic tank & motor would weigh considerably less than 8 ounces.

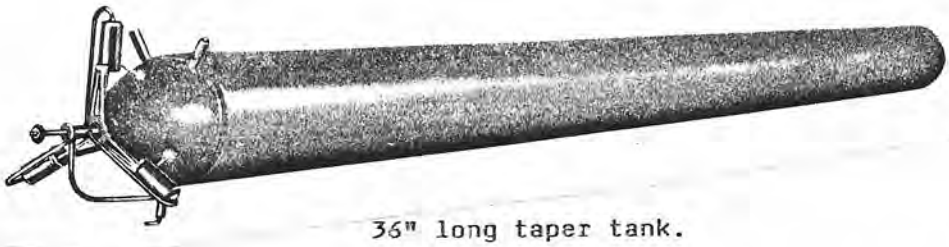
Test glide "in tall grass" as the saying goes until you find correct position of power plant for a smooth flat glide. Mark this position carefully so that you can relocate power plant accurately again without having to repeat glide test. For glide tests, placing a weight equal to propeller weight on propeller shaft could save damage to machine & propeller. Depending upon flying qualities, you may wish to add some suitable type of dethermalizer to this model.

Compressed-Air Driven Model

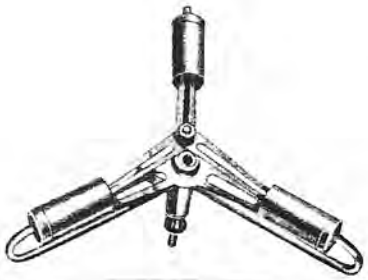
A Non-Scale Flyer

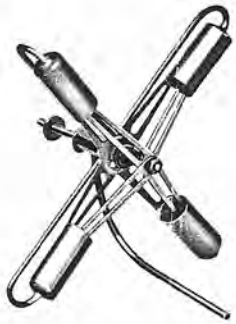


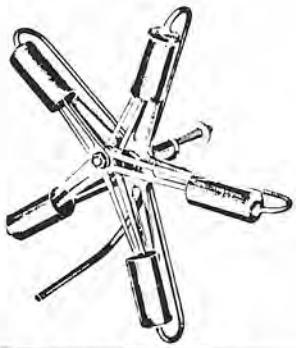
The motor tank or propeller are not shown, but the tank is fastened to the fuselage members.



36" long taper tank.







EARLY 3 CYLINDER----------4 cylinder------&---5 cylinder engines

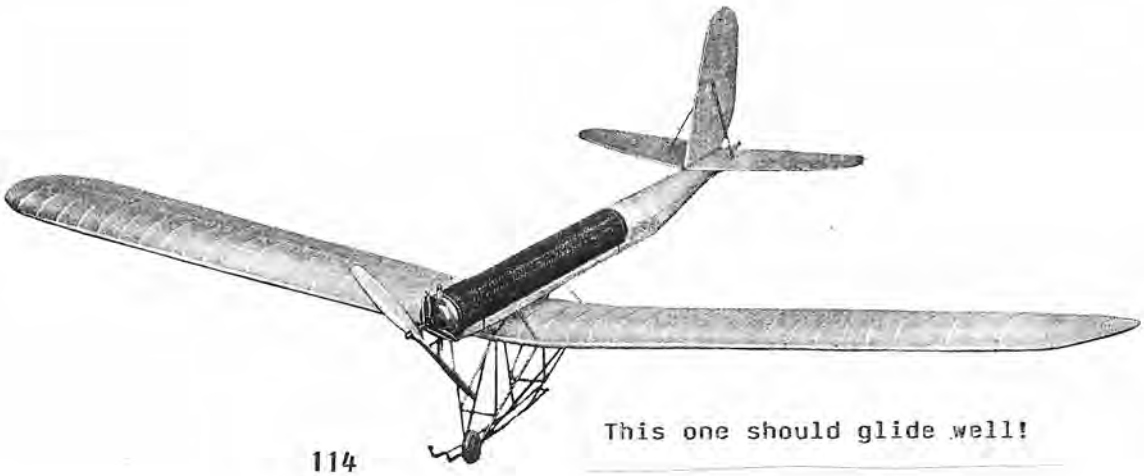




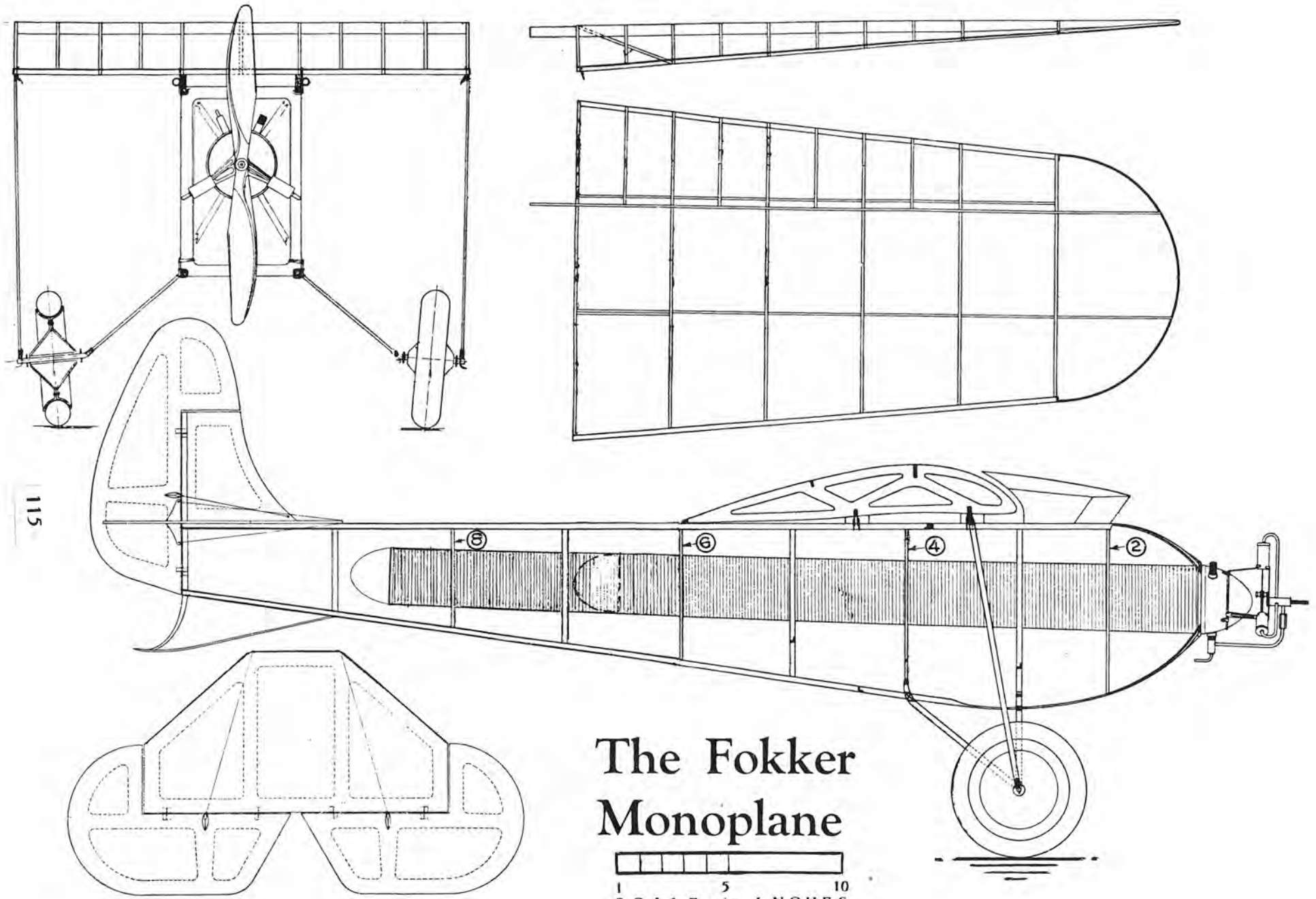
Later models using old parts surplus.



The short lived Dobe-Ott.

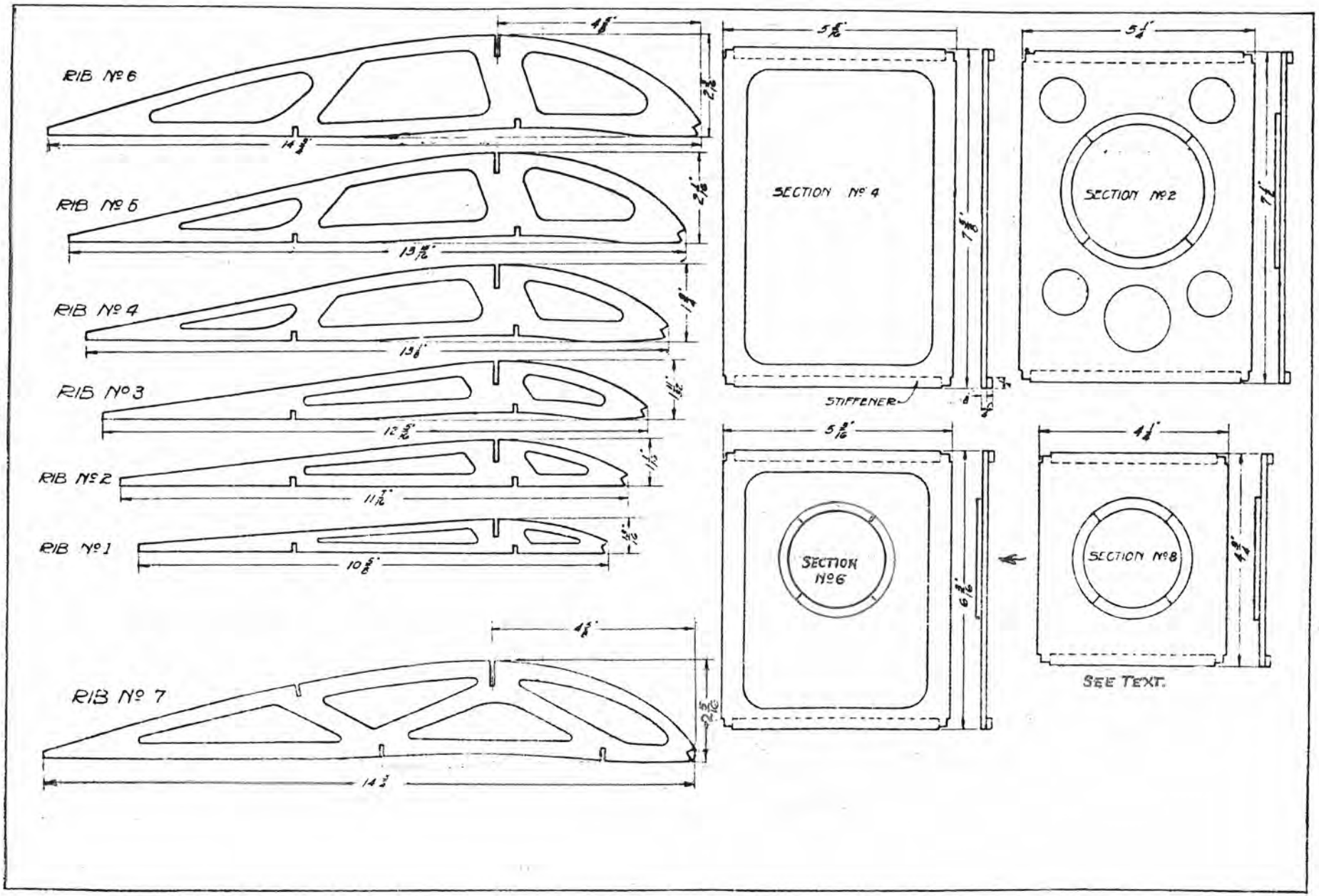


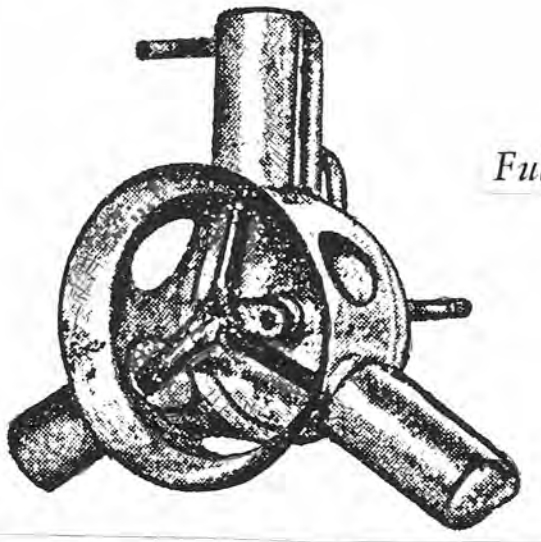
This one should glide well!



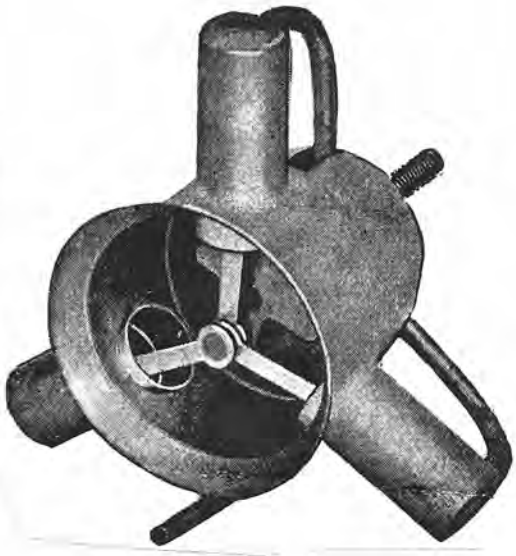
The Fokker Monoplane

1 5 10
SCALE in INCHES


RIB Nº 6
RIB Nº 5
RIB Nº 4
RIB Nº 3
RIB Nº 2
RIB Nº 1
RIB Nº 7
SECTION Nº 4
SECTION Nº 2
STIFFENER
SECTION Nº 6
SECTION Nº 8
SEE TEXT.

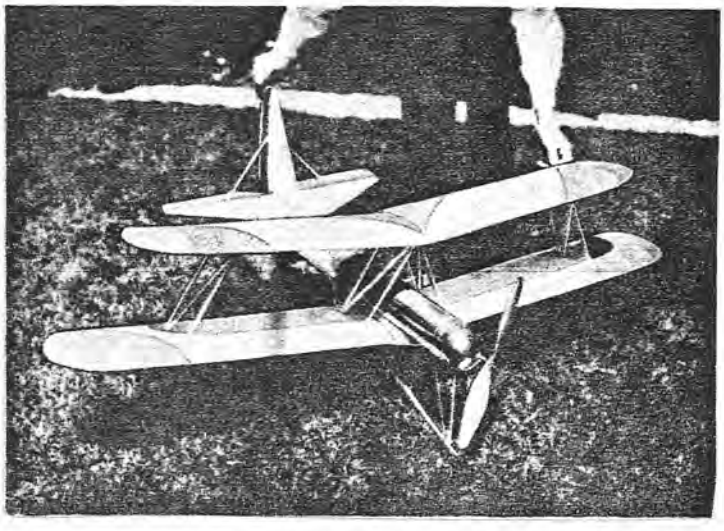


Full Size



Pause Motor-1914

Ott copy-1930



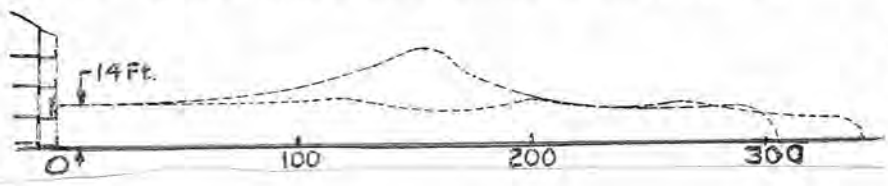
Ott Biplane

Ott 110" Span Take-apart Giant Model

LAWRENCE HARGRAVE & HIS AERONAUTICAL WORK.

Any discussion of expansion engine powered model aircraft should include the fabulous experiments of Lawrence Hargrave. Hargrave was born in England, but went to Australia to join his father, a lawyer, in 1866. After an apprenticeship with an engineering firm, he was employed by the Sydney Observatory. His duties included studies of air movements. His inquisitive mind became obsessed with the possibility of developing a machine for human flight. He decided to retire in 1883 & devote his time to aeronautical research. He exchanged ideas with Octave Chanute & other aeronautical experimenters. His research had to start with the basics.

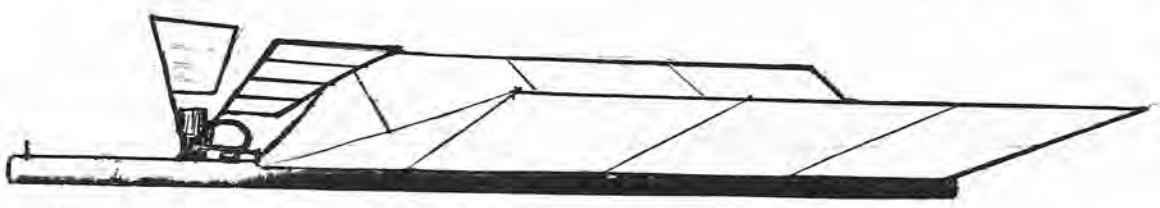
First he built & tested a means of propulsion patterned after birds. He arranged a music box spring to reciprocate a pair of winglike paddles in a manner similar to that of a bird's wings. This device was mounted at the end of of a balanced bar pivoted in the center. When wound up, the mechanical bird rotated the bar 3-1/2 feet for each flap cycle. The success of this experiment encouraged him & made flapping propulsion a popular choice in many future experiments. The heavy spring was replaced, at first, by stretched rubber operating the flappers through an elaborate system of block & tackle & a string rotating a crank to the flappers. After making about 50 of this type of rubber powered machines, he began planning on engine powered machines. He built steam powered expansion engines but there is no record of flights being made with them, but 270 feet had been made by rubber. He was unable to build a working gasoline engine so he turned to COMPRESSED AIR expansion engines. The first two were too heavy but the third one weighed in at only 7-1/2 ounces. It had a bore of .88" & a stroke of 1.30". The engine was a 3 cylinder rotary type. The ingenious Hargrave mounted propeller blades on each cylinder at an angle of 20°. The great power of compressed air may be appreciated by the fact that this little engine propelled a 36-1/4" diameter 3 bladed propeller at 456 rpm. with an average air pressure of only 135 psi.



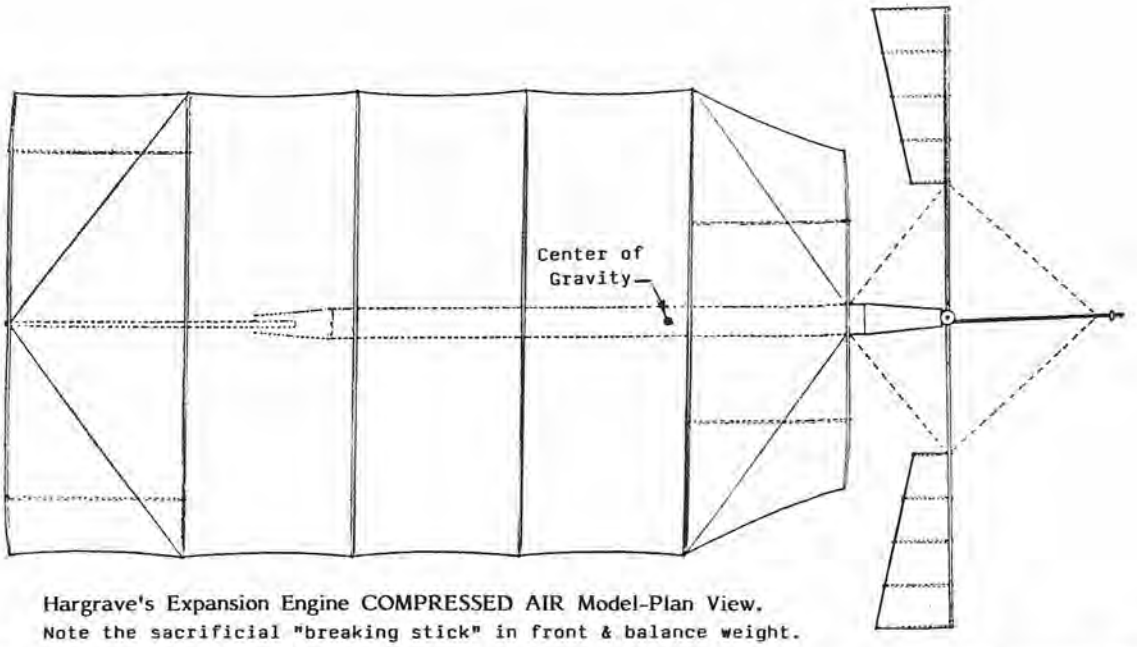
The chart at the left shows the 2nd floor launching station. The models were launched from a height of 14 feet. above ground level. The tabulation below the chart compares 12 of Hargraves flying machines, 10 rubber powered & 2 COMPRESSED AIR expansion engine powered. Hargrave was meticulously thorough in all of his work. He counted the number of flaps with a gear wheel & ratchet device. For the propeller models, he wound a string on a bobbin in order to count the turns made during the flight.

COMPARISON OF FLYING MACHINES.

Observations made with—	Total area. sq. in.	Sq. in. area per lb. weight.	Weight. lb.	Distance flown. ft.
24 Band A	1,236	841	1·47	120
„ B	1,381	1,132	1·22	170
„ C	1,177	997	1·18	201
48 Band F	1,606	873	1·84	189
„ G	1,551	843	1·84	171
24 Band H	1,986	1,555	1·28	192
„ J	1,974	1,542	1·28	203
„ K	1,974	1,542	1·28	209
48 Band L	2,130	1,019	2·09	270
48 Band—Screw	2,090	1,045	2·00	120
40·5 oz.—Compressed air	2,344	925	2·53	368
74 oz.—Compressed air	4,266	922	4·63	343

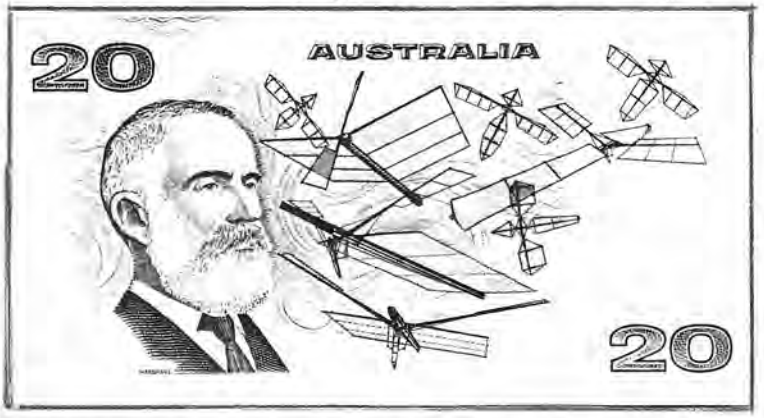


Hargrave's Double Acting Expansion Engine Flapper Model Aircraft.



Hargrave's Expansion Engine COMPRESSED AIR Model-Plan View.
Note the sacrificial "breaking stick" in front & balance weight.

Hargrave's nomenclature was a bit confusing because, in his writings , he called the main wing the"body plane". He called the flappers the"wings". The flappers, as shown in the plan view, are wider than the span of the "body plane" wing! In some of his models, the flappers spread over 6 feet from tip to tip.
Hargrave's test seemed to indicate that flappers & propellers were about equally efficient. The torque of the propeller caused him to "discover" the stabilizing effect of dihedral. Then he retained dihedral in all subsequent designs including the flappers.
The "breaking stick" was Hargrave's method of reducing damage to the motor & other front end components. In a bad landing the stick would absorb the impact. The stick served to brace the flappers & to mount lead weights for correcting longitudinal balance.
Hargrave felt that he should study curved surfaces as another step in developing his aircraft designs. In this process, he developed the box kites for which he is well known. He demonstrated the great lifting power of his kites by lifting a weight of 208 pounds with a string of his kites. Hargrave was part of this weight & was lifted 16 feet in the test. The wind velocity was 21 miles per hour.
In review, Hargrave had built & flown a great number of odd looking models by todays standards. The first flights were with rubber stretch powered models. He tried most all ideas which came to his mind. He tried steam & gasoline but was not successful in flying models with these engines.



[Reproduced 2/3 size by permission Australian Government]

His successful expansion engine model flights were all made with COMPRESSED AIR engines. He used 3 cylinder rotaries & radials & single cylinder double acting types. They were all very powerful. The tanks were small diameter & NOT wire reinforced. The Australians like to claim that Hargrave invented the rotary engine which he may well have done.
An Australian Model Engine Co. had planned to replicate the the rotary engine but dropped the effort due to lack of response. Hargrave died in 1915. He was honored by having one side of the $20.00 Australian bill depict 8 of his models & showed his portrait. See above 2/3 copy.

D. A. Pavely-Legendary English COMPRESSED AIR Model Expert.

Mr. D. A. Pavely was one of England's great old time model fliers. He experimented with most all types of models from rubber driven twin pushers to COMPRESSED AIR powered models. In the summer of 1985 at Old Warden flying grounds in England I had the privilege of assisting in a flying demonstration of an original D. A. Pavely twin pusher model. I was able to note Pavely's workmanship. The model which was well over 50 years old flew perfectly. This model had been restored to its original flying condition by Mr. Alwyn Greenhalgh.

In 1947 Pavely authored two articles for Aeromodeller magazine. One was titled "Flash Back——Compressed Air Jobs" appearing in the September issue. The other was titled "Compressed Air for the Future" appearing in the December issue. According to Pavely it would require a book to record all COMPRESSED AIR expansion engine & model experimentation. Pavely's "Flash Back-----" article records most of important events in development of COMPRESSED AIR power beginning with a brief outline of Lawrence Hargrave's work. Then from 1913 forward he recorded in more detail a series of COMPRESSED AIR happenings. The Kite & Model Aeroplane Association of England conducted what was probably the first model aircraft contest for models powered other than with rubber. This event was held in March of 1913 at the Herndon Airdrome grounds. Models entered included gasoline engine powered ships and expansion engine craft with steam, CO_2 & COMPRESSED AIR for power. Mr. H. Groves & his steam powered monoplane won with a flight of 40 seconds. A French rotary engine COMPRESSED AIR powered model took second place with a 35 second flight. This French model was framed with small aluminum tubing. Air was carried in two aluminum tanks 1-1/4" in diameter & 20" long. Pavely noted particularly that this machine flew quite well with a large diameter propeller rotating at a relatively slow rate.

This power model meeting was an inspiration for many aeromodellists who saw an engine powered model fly for the first time.

Pavely was employed by T. W. K. Clarke & Company- model makers. One of his jobs was to construct a model aircraft with a French made COMPRESSED AIR power plant in 1914. This model was exhibited at Olympia & was entered in competition at the Herndon Airdrome grounds. Although this model took off under its own power & flew it was somewhat underpowered & did not place in this contest.

A model, the work of both Mr. Hiscox & Desoutter, got off & flew quite well until it hit an automobile. (Sound familiar?)

About June 1914, a German made Bing Autoplan COMPRESSED AIR powered model aircraft became available worldwide. Aeromodelers were quick to extract these Bing power plants from the whole ship & adopt them to their own-hopefully better-home brew model designs. By August of 1914, three of these ships were flying frequently at Wimbledon Commons. Fliers were getting 15 to 25 seconds duration on as little as 50 psi air pressure. Mr. Hiscox lightened his Bing Autoplan power plant by drilling holes where ever possible & mounted it in a twin float tractor seaplane. It made flights by actually taking off of the water under COMPRESSED AIR power.

In October 1914, Mr. Laing, with the assistance of 3 other people to pump up his air tank, made a 43 second flight record. Mr. Pavely was quick to note that the pressure on this flight was not known & therefore was an unsafe & hazardous procedure. By November of 1914 the squadron of compressed air fliers had doubled. It included Mr. V. E. Johnson, model editor of "Flight" & author of the book "Model Aeroplaning," D. Laing, Bragg-Smith, C. Desoutter, C. Haydon, Hiscox & of course D. A. Pavley a professional model maker. Haydon made his own power plant & his model flew quite well.

Unfortunately the Great War-WWI-got under way & model aircraft activities other than making aircraft spotter training & recognition models came to a distinct halt. Pavely did make some experimental engines during the war. However he did not build any models for these engines.

Early in 1919, Pavely, being a model maker by profession, decided to manufacture some compressed air models & market them under the logotype "D.A.P." With help from his brother, after much experimentation & flying tests at Wimbledon, a number of tractor monoplanes were produced. They had large 18" diameter 24" pitch French type of slow turning efficient propellers. An opposed twin air expansion engine was fed by a

3" diameter by 24" long air tank. Wing span was 72 inches. Weight of model "dry"- without air pressure in tank-was 24 ounces. A second model was developed. It was a biplane with a larger air tank but with the same engine size. Both models flew quite well & were sold through Gamages & similar outlets.

About this time period the London Aero Models Association was organized. Later it became SMAE, Society of Model Aeronautical Engineers. Competitions were held at regular intervals. At first, COMPRESSED AIR models were allowed to compete on an equal basis with other types of models. In 1923, rules for the Gamage Cup & Model Engineer competitions placed handicaps on COMPRESSED AIR models. Other types of models were given bonus points for rising off of the ground & for fuselage type of construction but not COMPRESSED AIR models. Rules required that COMPRESSED AIR power plants could be withdrawn from the plane same as a rubber motor. These rules were the result of better average performances by COMPRESSED AIR models & a desire to equalize the chances of winning events. However COMPRESSED AIR models kept on winning.

In the Kelly Cup competitions initiated in 1922 the rules stipulated that any person winning the event 3 times consecutively became the permanent owner of the cup. Also the rules required a minimum weight of 16 ounces & a minimum wing loading of 8 ounces per square foot. In the competition, C. A. Rippon's Farman type model flew very realistically but made only 35 seconds. Pavely was more fortunate. His winning time of 70 seconds broke the record for COMPRESSED AIR models. It was many years before this 70 second record was broken by later state of the art Whirlwind powered models. Pavely stated that this model weighed about 48 ounces. He used a three cylinder radial engine fed from a 4" diameter by 24" long air reservoir & driving a large slow turning French type of propeller.

In 1923, Pavely won the second leg of the Kelly Cup competition. This time he used two 3" diameter air tanks placed one above the other & a slightly smaller motor than was used in his 1922 machine.

In 1924 Pavely managed to make over the required 60 seconds with a model similar to his 1922 plane thereby winning the Kelly Cup permanently.

Pavely cited numerous other modelers who built COMPRESSED AIR models. Among these was R. J. Trevethick whose streamlined model is illustrated in "The History of Model Aircraft". Another was F. A. Lowe who designed the "Crusader" as detailed in 1932 in "The Model Engineer & Practical Electrician." COMPRESSED AIR models competing with other types won the Sir John Shelley Cup each year up to 1930. With all of this success of COMPRESSED AIR models, Pavely was at a loss to understand why they were not more popular.

Pavely's last COMPRESSED AIR model earned for him second place in the 1929 Wakefield Cup competition. It is interesting to note that COMPRESSED AIR models were allowed to compete in the Wakefield Cup event at that time & placed as high as second place!

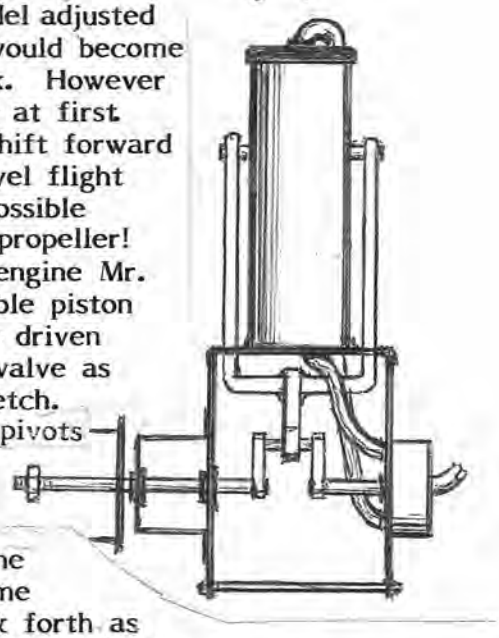
Pavely cites the change in technique from longest possible propeller run to that of climbing highest possible quickly & relying on glide soaring & thermals for duration. Pavely contended that with some continued experimentation COMPRESSED AIR model duration could be vastly improved. Actually it has, but there is much more which could be accomplished.

Pavely was quite proud of the fact that he beat Stanger's gas model record of 51 seconds.

Pavely outlined his ideas of what features would make better, more efficient engines. Much attention should be given to the reduction of air leakage & air losses. Feed pipes should be as short as possible between valve & cylinder head. These feed pipes are filled & emptied once in each revolution & the air volume in them is wasted when the exhaust valve opens. Clearance between top of piston & inside of cylinder head should be as small as possible because any excess volume here is also wasted & further there is a loss in expansion ratio. Friction should be minimized where ever possible. Small diameter valves should keep friction low there. Valve openings or windows should be generous to avoid undue pressure loss. All tanks should be tested to a higher pressure than it is ever intended to be used. Since containers can deteriorate from stress, strain & corrosion they should be retested periodically. Pavely suggests that adequate safety precautions be taken during testing operations.

Pavely advises oiling engines before each flight. However NEVER put any oil in the tank. With the air being concentrated, he believed that oil plus oxygen could be an explosive situation. In one tank test to destruction around & behind a door opening, he thought that there was a flash of light when the tank let go with a big bang. It is good advice; so just oil the engine & do not put oil in the tank!

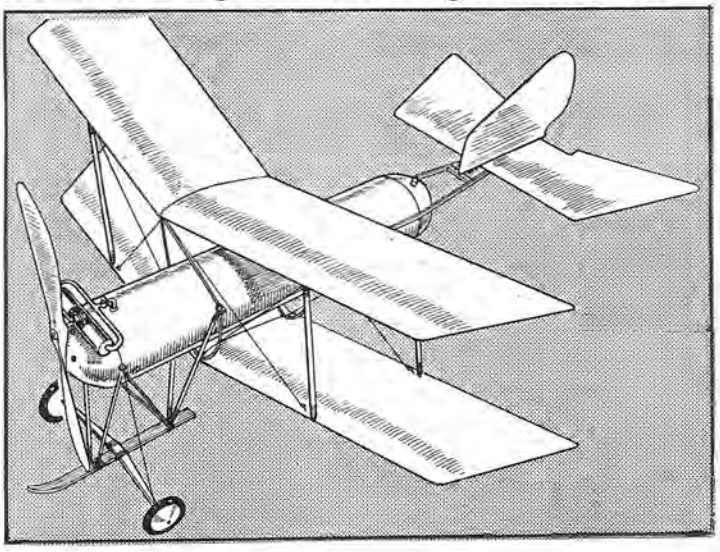
Pavely's winning technique was to test the maximum initial thrust of his power plant. Then the total model must not weigh any more than TWO times this maximum thrust. Then he would place the center of the air volume & weight of air slightly behind the center of gravity of the model. Then with the model adjusted for optimum glide WITHOUT air pressure in tank it would become somewhat over-elevated with air pressure in the tank. However the initial power would cause model to climb steeply at first. Then as air was consumed, center of gravity would shift forward as model gained altitude. It would then cruise in level flight at its zenith & assume a decent glide angle in any possible thermals. Pavely's only pressure regulator was the propeller!



The rough sketch on the right is that of an unusual engine Mr. Pavely built in 1914 & is worth description. A double piston arrangement with leather cup washers on each end is driven alternately in each direction by air from the rotary valve as shown on the right hand side of the frame in the sketch. A "Y" shaped yoke along the outside of the cylinder pivots at its upper end on a long wrist pin equidistant between the pistons. The wrist pin projects out of a 5/8" long slot in each side of the cylinder. The other end of the yoke engages the crankpin in the same manner as a connecting rod. Slots in the frame provide clearance so that the yoke may swing back & forth as it drives the shaft. The bore is 3/4" & stroke is 1/2". Weight of the engine is 3-3/4 ounces. Mr. V.E. Johnson, the model editor of "Flight", tested this engine for Mr. Pavely. Johnson's test showed that the motor could handle a 16" diameter propeller quite effectively. Air leakage was negligible. Mr. Johnson made the suggestion that two of these double acting cylinders could be joined at a 90° vee making a 4 stroke per revolution engine. Such an engine would have a smooth flow of power. Such a project could test the mettle of some inspired COMPRESSED AIR experimenter!

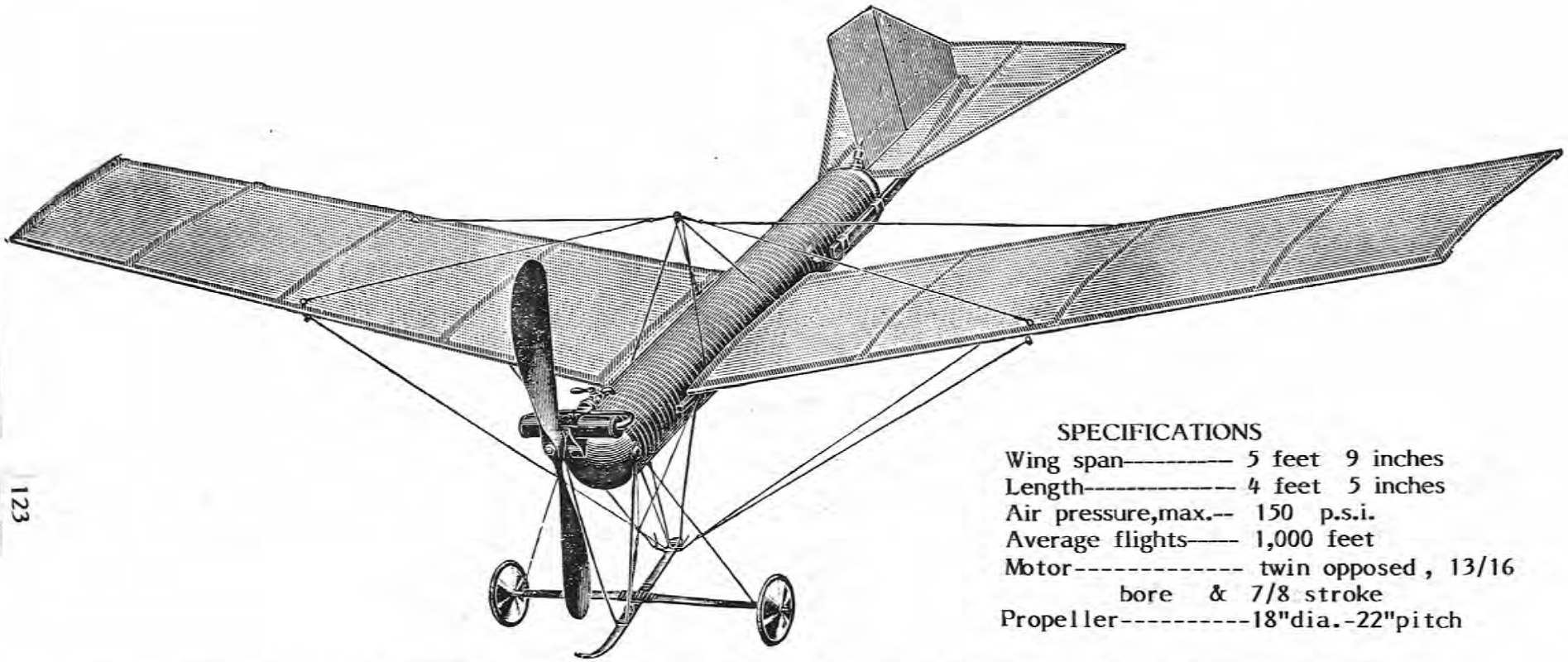
Pavely did not have electric air pumps which plug in the cigarette lighter socket in an automobile so he had to pump with a hand job. He found that a 1-1/2" bore was almost too large a size for comfort. He found that a 1-1/16" diameter bore pump was best since he could attain 150 psi. without undue fatigue.

Pavely favored two cylinder engines for maximum efficiency. He liked 3 cylinder engines because of smooth flow of power & because they would start without having to flip the propeller. I am sure that Mr. Pavely would have found the walking beam twin in line engine to his liking as a most air efficient engine.



On the left is a drawing of Pavely's biplane model from Aeromodeller. Pavely's use of the tank as part of the structure places added duty on the tank including localized higher stress areas. The air outlet from tank to engine would better be put in lower stressed end cap. Pavely used central tie rods "to retain the end caps". This has been found to be entirely unnecessary. However, all in all, Pavely did a marvelous job with his COMPRESSED AIR engines & models.

With his death in the late '60s, modelers lost a great man.



SPECIFICATIONS

Wing span---------- 5 feet 9 inches
Length---------- 4 feet 5 inches
Air pressure,max.-- 150 p.s.i.
Average flights---- 1,000 feet
Motor---------- twin opposed , 13/16 bore & 7/8 stroke
Propeller----------18"dia.-22"pitch

1914 COMPRESSED AIR MODEL as sold by Gamage in London. D.A.Pavely made & sold identical models under name D.A.P.Model Engine Company.

Col. Bowden's book "The History of Model Aviation" states on page 14 that the Pavely's record holding model had a wingspan of 90" ; a wing chord of 9" ; a length of 42" ; & weighed 28 ounces. The illustration of this record model appears to be identical to the model pictured above except that the rudder is reversed with the slanting portion of the rudder on the forward side rather than on the rear.

HOWARD McENTEE'S COMPRESSED AIR MODEL-"WHEN AIR CONQUERS AIR"

Howard McEntee believed that ordinary air compressed into a tank & driving an air motor which turned an air propeller which thrust itself through the air pulling a model airplane with wings which rode on air would be truly- "AIR CONQUERING AIR". So Howard set about to design & build this C.A. model airplane.

Please study the drawings carefully before building. Also review the Bill of Material listed on the right.

Note that Howard used a pine propeller- 15" diameter x 15" pitch. A hard balsa propeller would be lighter & easier to carve too. He used a 2-1/2" dia. x 24" long tank. The motor run on a bit larger tank would have given a bit longer flight.

In general, the fuselage is made in the usual manner. The longerons could be reduced in cross section however. 3/16" or even 1/8" toward the rear would be adequate.

A ring of .064" dia. music wire drawn around the tank with rubber bands is used to keep the tank in place. Bamboo strips bound to the ring provide a nose like a real airplane.

The rear of the tank is supported by a balsa bulkhead with a hole to fit the tank. The bulkhead is made of 2 pieces of sheet balsa glued together with the grain at 90° angle to each other.

A 3" diameter aluminum cowl over the motor & windows of plastic helped to make the plane look like a stand-off scale of some real plane.

In order that he could take the model apart readily, he used wire clips & rubber bands as shown on his drawings. Notice that he used a brace on the elevator to the rudder made of #8 music wire, or heavy thread.

BILL OF MATERIALS-

- 8- 1/4" square x 3 ft.balsa
- 10- 1/8" x 1/4" x 3 ft.balsa
- 4- 1/8" square x 3 ft.balsa
- 3- 3/16"x 1/2" x 3 ft.balsa
- 3- 1/2" square x 3 ft.balsa
- 1- 1/8" x 1/2" x 3 ft.balsa
- 1- 1/4" x 1-1/2"-3 ft.balsa
- 2- 1/16"x 3" x 3 ft.balsa
- 1- prop block 1" x 1-9/16" x 15"pine
- 2- 3" dia.balloon wheels balsa
- 1- 4" x 14" plastic window material
- 1- 1" dia. tail wheel
- 1- 1/16" dia. x 1 ft. aluminum tube.
- 4- ft. #16 music wire
- 3- ft. #8 music wire
- 1- 1/4" dia. x 1 ft. aluminum tube
- 1- 1/4" dia. x 1 ft. dowel (birch)
- 1- 3" dia. x 1-1/2" deep aluminum cowl
- 1-air tank 2-1/2" dia.x 24" long
- 1- 3 cylinder motor(Whirlwind used)
- 2.5 square yards of model silk
- Misc. thread, rubber, dope, glue, bamboo, etc.

McEntee's wing is made in two sections joined with dowels & aluminum tube. The wing would be much stronger if made in one piece. The center is the weak spot & the dowel is sure to break sometime in a stiff wind or bad landing.

The wing is held to the fuselage with rubber bands & wire hooks. 1/4" center ribs are not required in a one piece wing.

For lightness, 1/2" diameter hole can be made in the false ribs. I have added optional holes in the main ribs, too. Lightness is the name of the game.

Note the short pieces of aluminum tube 1/16" diameter used for rudder & elevator hinges, along with that #8 music wire for hinge pins. Use care in aligning the short aluminum hinge pieces.

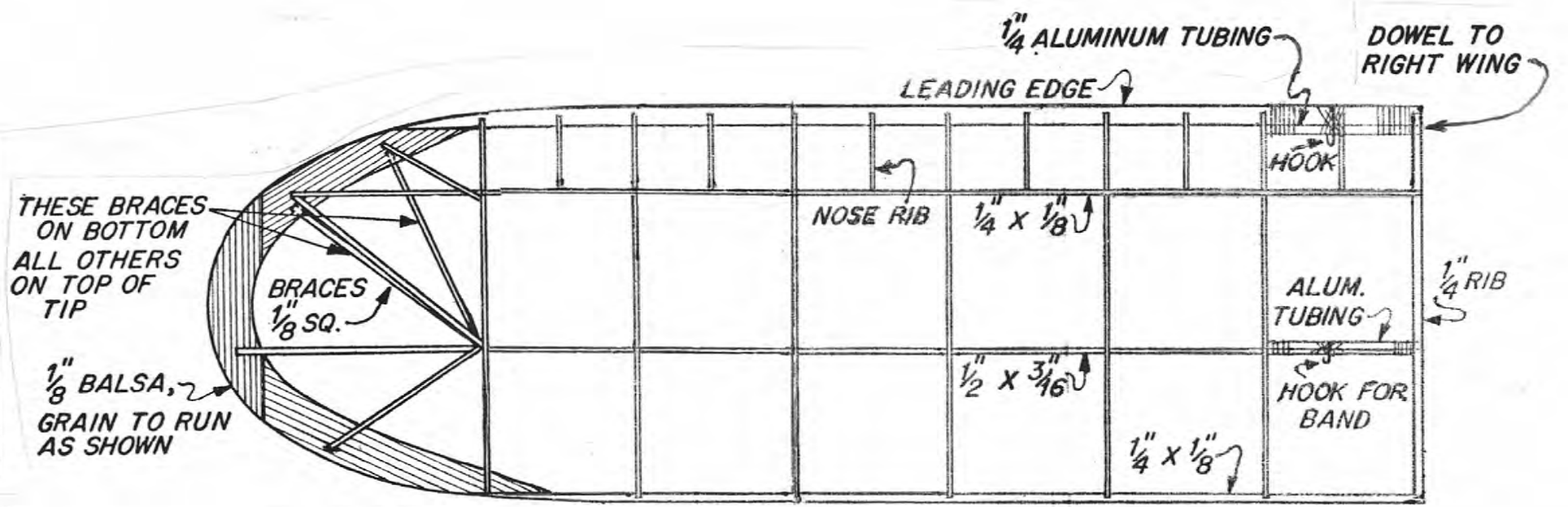
Tissue covering is suggested over silk as it is lighter, cheaper & does not tend to pull the wing out of shape as much as the silk.

Folding propeller is suggested in order to minimize damage if model hits something.

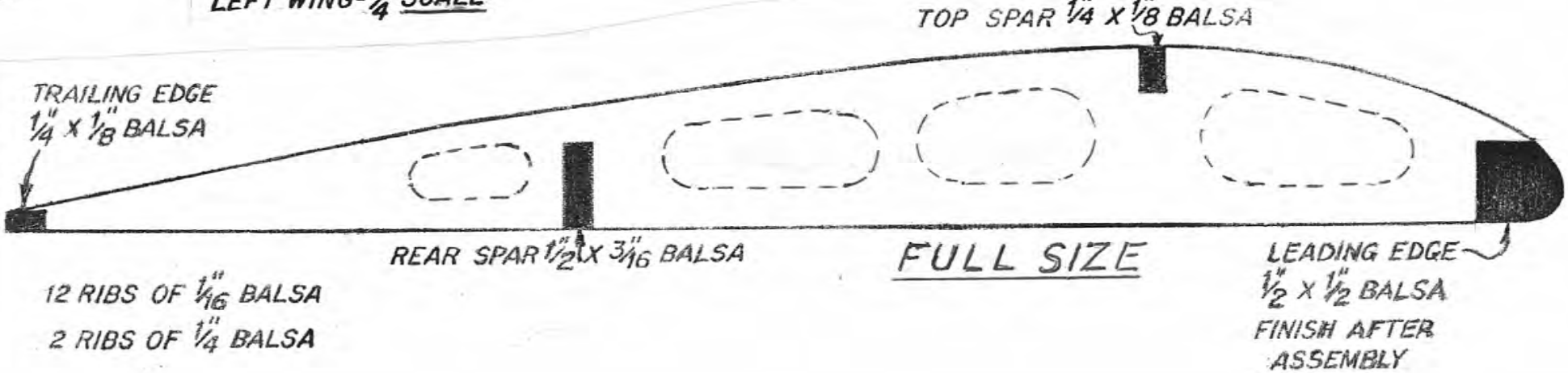
Build the wing & body over a full size plan as laid out on a FLAT building board. Use several coats of cement on all joints. Build the ship like you would a Wakefield model-light, strong & with care.

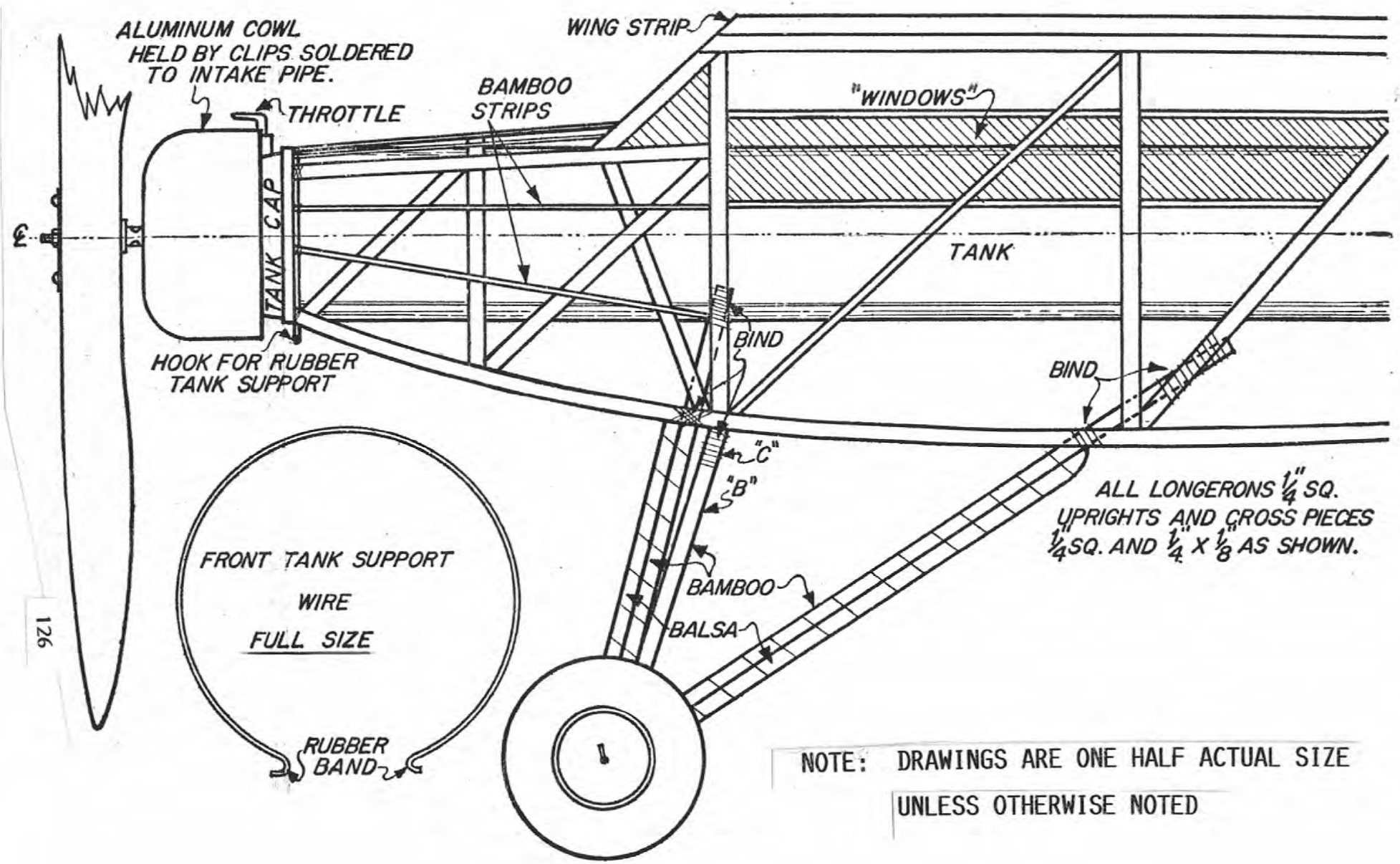
Use a good air pump of one of the types described in the pump section & have fun.

(For plans, see pages 125 through 129)

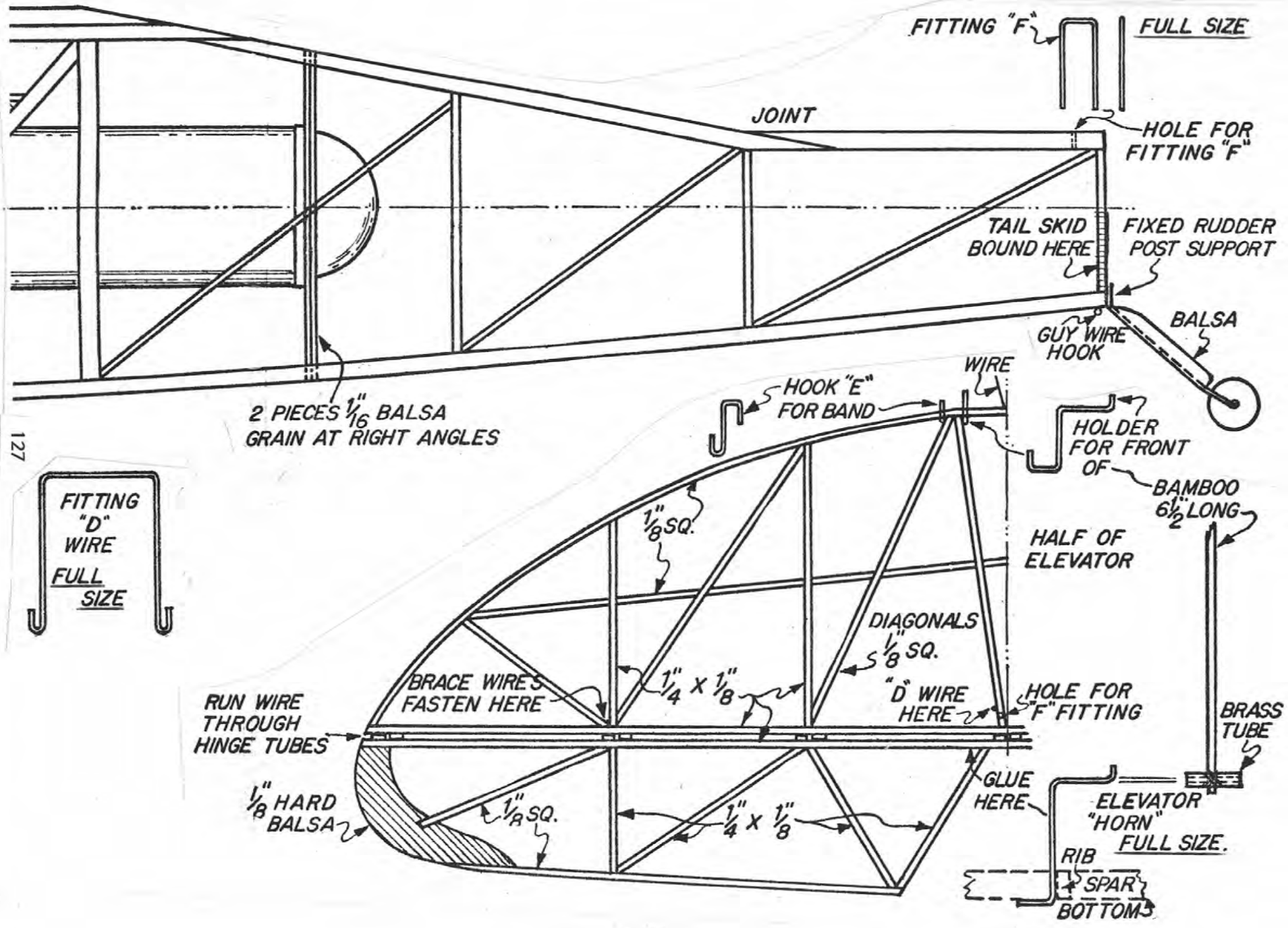


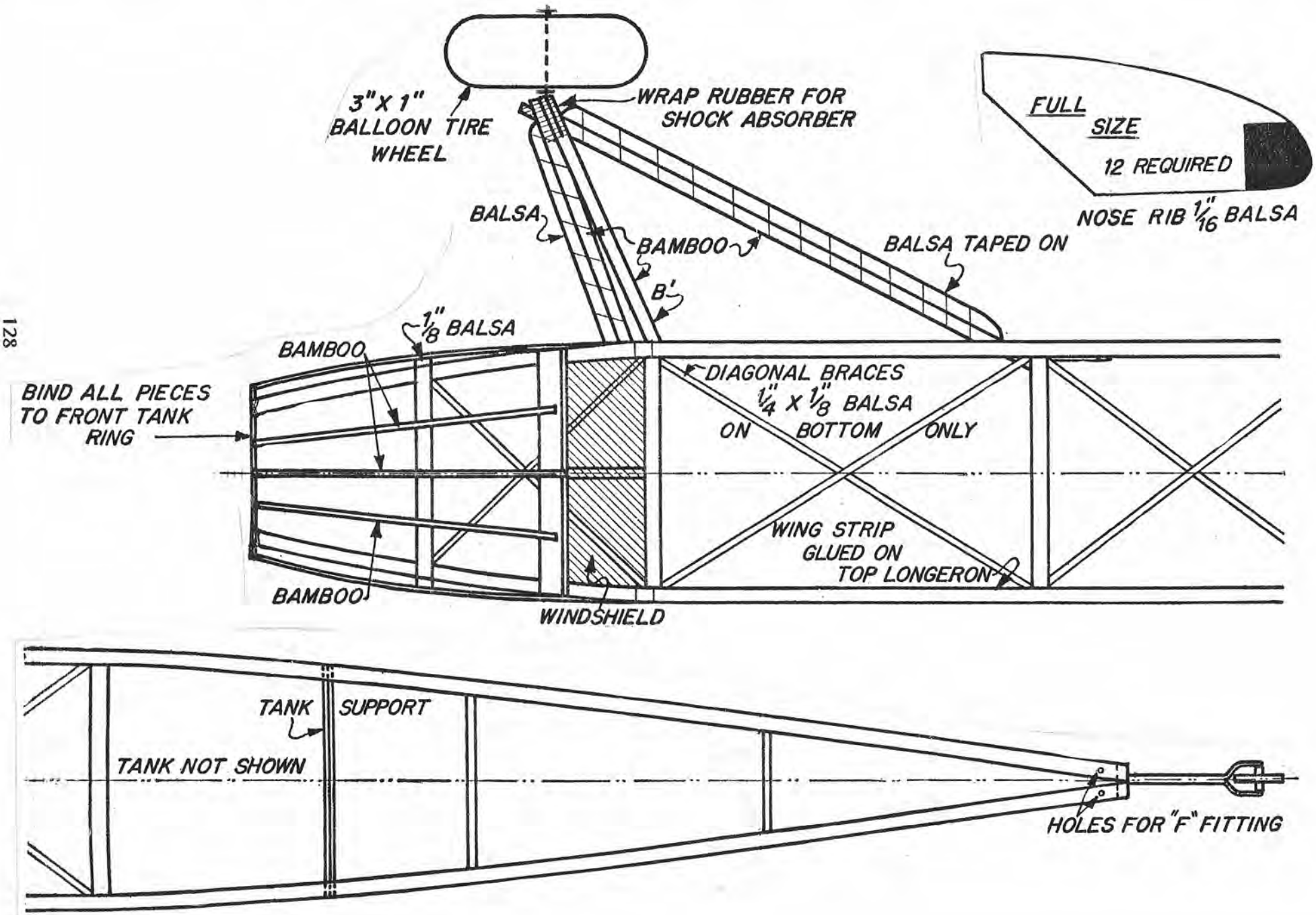
LEFT WING-1/4 SCALE

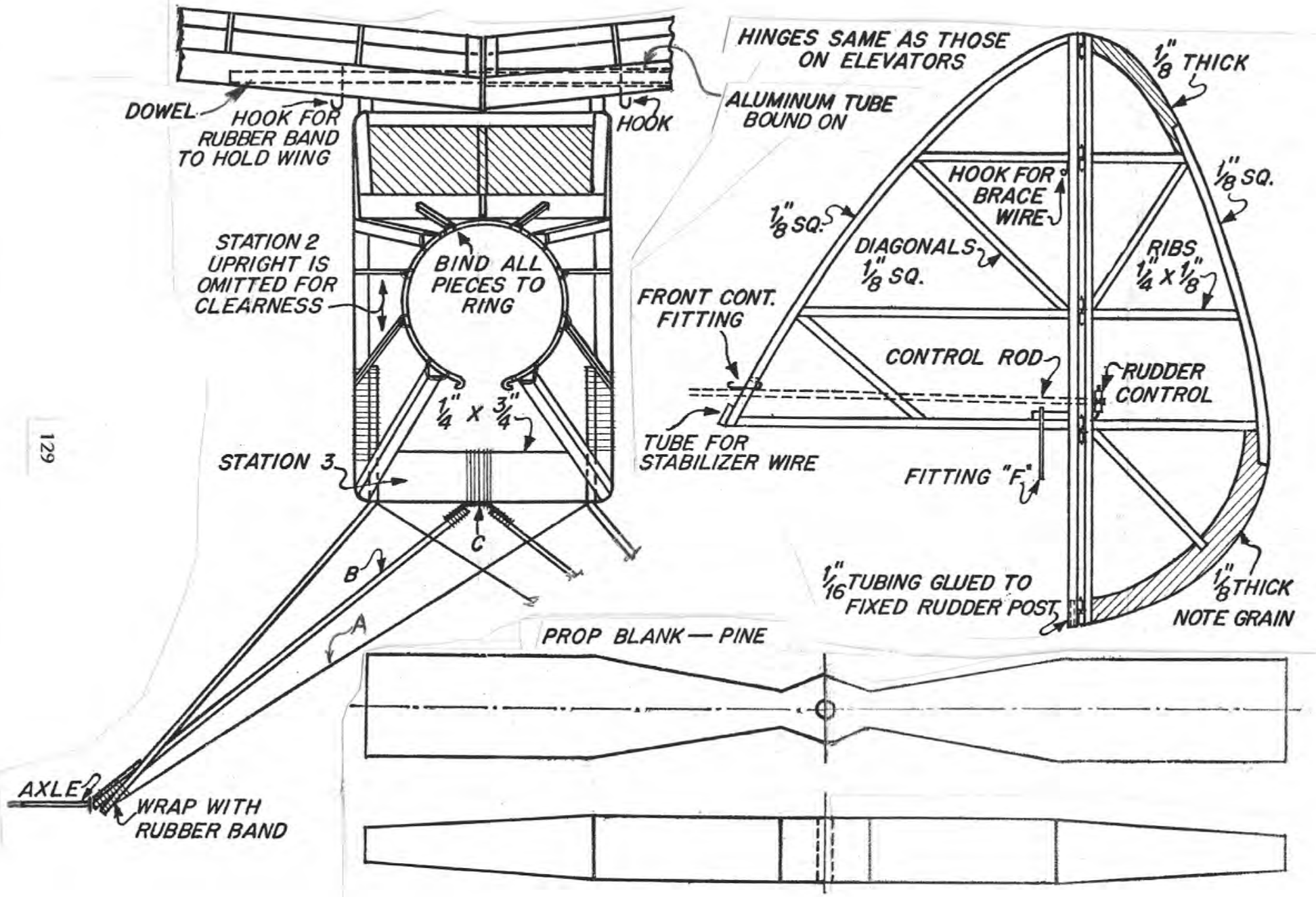




NOTE: DRAWINGS ARE ONE HALF ACTUAL SIZE
UNLESS OTHERWISE NOTED

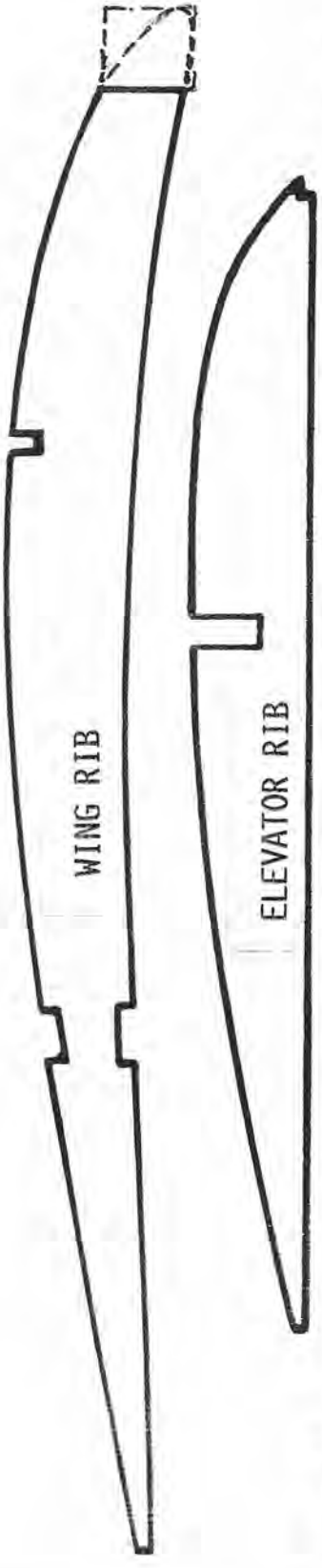

FITTING "F"
FULL SIZE
JOINT
HOLE FOR FITTING "F"
TAIL SKID BOUND HERE
FIXED RUDDER POST SUPPORT
BALSA
GUY WIRE HOOK
WIRE
HOOK "E" FOR BAND
HOLDER FOR FRONT OF
BAMBOO 6½" LONG
2 PIECES 1/16 BALSA GRAIN AT RIGHT ANGLES
FITTING "D" WIRE FULL SIZE
1/8 SQ.
HALF OF ELEVATOR
DIAGONALS 1/8 SQ.
BRACE WIRES FASTEN HERE
1/4 X 1/8
"D" WIRE HERE
HOLE FOR "F" FITTING
BRASS TUBE
RUN WIRE THROUGH HINGE TUBES
1/8 HARD BALSA
1/8 SQ.
1/4 X 1/8
GLUE HERE
ELEVATOR "HORN" FULL SIZE.
RIB
SPAR
BOTTOM


3"X 1" BALLOON TIRE WHEEL
WRAP RUBBER FOR SHOCK ABSORBER
FULL SIZE
12 REQUIRED
NOSE RIB 1/16" BALSA
BALSA
BAMBOO
B'
BALSA TAPED ON
1/8" BALSA
BAMBOO
BIND ALL PIECES TO FRONT TANK RING
DIAGONAL BRACES 1/4" X 1/8" BALSA ON BOTTOM ONLY
WING STRIP GLUED ON TOP LONGERON
BAMBOO
WINDSHIELD
TANK SUPPORT
TANK NOT SHOWN
HOLES FOR "F" FITTING


DOWEL
HOOK FOR RUBBER BAND TO HOLD WING
HOOK
STATION 2 UPRIGHT IS OMITTED FOR CLEARNESS
BIND ALL PIECES TO RING
1/4" X 3/4"
STATION 3
C
B
A
AXLE
WRAP WITH RUBBER BAND
HINGES SAME AS THOSE ON ELEVATORS
ALUMINUM TUBE BOUND ON
1/8" THICK
HOOK FOR BRACE WIRE
1/8" SQ.
1/8" SQ.
DIAGONALS 1/8" SQ.
RIBS 1/4" X 1/8"
FRONT CONT. FITTING
CONTROL ROD
RUDDER CONTROL
TUBE FOR STABILIZER WIRE
FITTING "F"
1/16" TUBING GLUED TO FIXED RUDDER POST
1/8" THICK
NOTE GRAIN
PROP BLANK — PINE

COMPRESSED AIR MODEL. Easy to Build & Fly.

This COMPRESSED AIR model was made in 1929. A number of well known early model fliers including Tudor Morris & Tom Laurie built & flew this model. Plan gives all of details needed to construct this elementary ship. Full size rib patterns for wing & elevator are shown on left. Use care in making all 14 ribs in wing & elevator alike.



Bill of materials for this model:-

2- 7/16" square x 40" long balsa---	entering edge
5- 3/32" x 5/32" x 40" long balsa--	trailing edge
1- 1/16" x 2" x 40" long balsa----	ribs
6- 3/32" x 9/32" x 40" long balsa--	wing beam-rear
1- 5/32" x 3/8" x 18" long balsa---	elevator beam
1- 1/8" x 1/4" x 20" long balsa----	rudder brace
1- 1/16" x 2" x 20" long balsa-----	ribs-tail
2- 7/32" x 9/16" x 38" long balsa--	body longerons
1- 9/16" square x 9" long balsa----	body cross pieces
2- 5/8" x 2-5/8" square balsa------	wheels
1- 1/16" x 1/4" x 4" long bamboo---	tail skid
4- 3/32" x 1/4" x 15" long bamboo--	landing gear
1- 1/8"dia. x 12" long brass tube--	axle
4- #2-56 x 1/2" long bolts & nuts--	attaching gear
4- #2 washers ----------	for above
4- #6 washers ----------	wheels
3- sheets Japanese tissue----------	covering

Cement & dope as required.

Cyanoacrylate cement will be helpful to make a stronger & lighter model-faster too! Avoid fumes.

Note that wing beams are well reinforced at center where greatest bending moment occurs. Grain of "I" beam web pieces can be vertical or at 45° angle to better resist shear. Fit these pieces closely & cement in place with 100% joint.

True length of landing gear struts is indicated. Struts should be streamlined. Wheels can be made by spinning wheel blocks & using a pointed tool to shape contour. Sand LIGHTLY & dope with several coats. Cement washers for bearings. Be sure wheels are same diameter! & that they rotate without wabble.

All surfaces are covered on both sides.

Note that wing center two ribs straddle fuselage. Wing is adjustable for proper balance.

Entering edge of wing may be made hollow by a groove tapering in depth from zero at center to 5/16" deep at tips. Any weight saved will allow faster climb & longer glide.

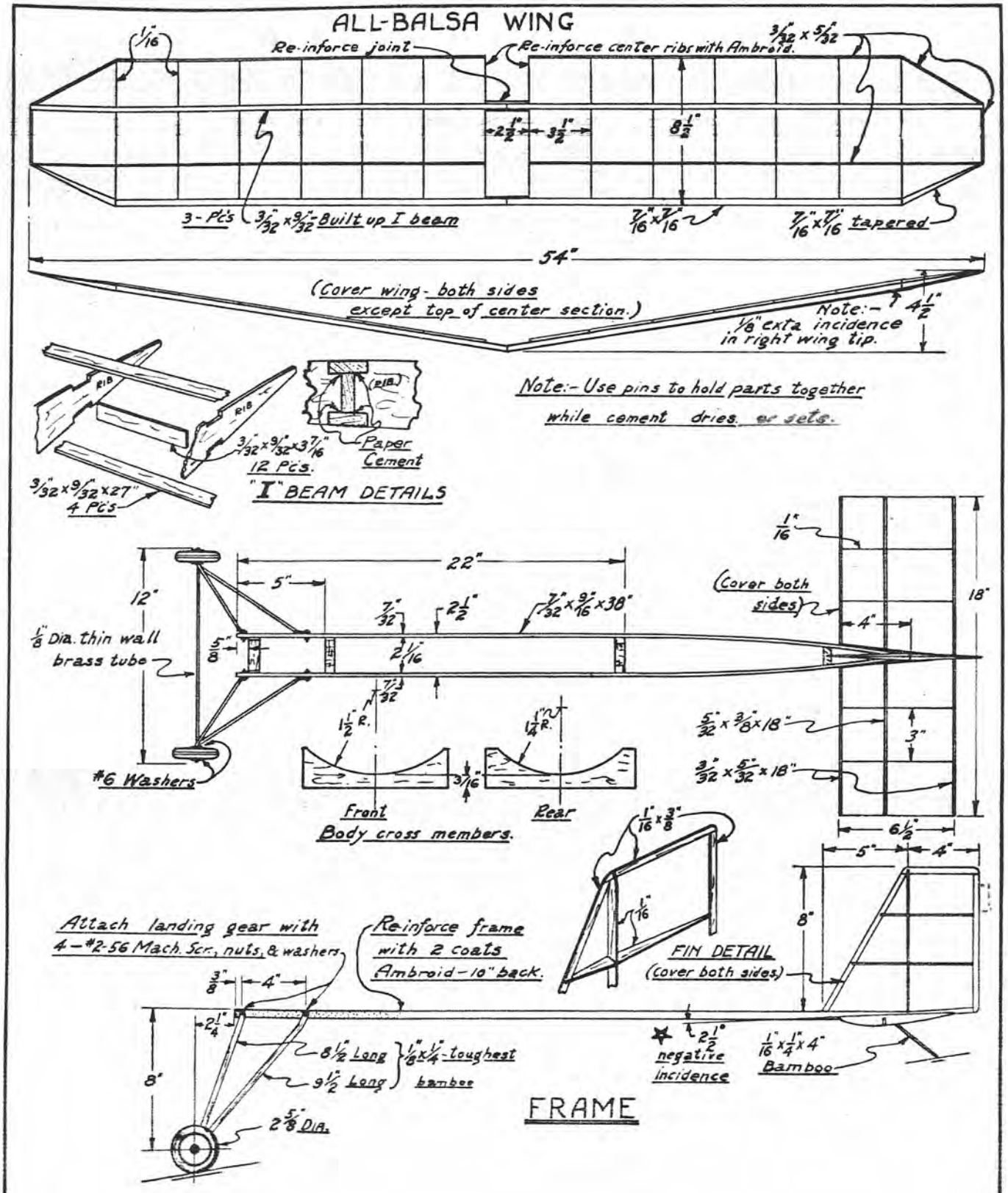
For those who can't bend bamboo, angle pieces of 1/16" x 1/4" aluminum may be used to fasten struts to fuselage.

Different diameters of tank than used on original model should have matching curve in fuselage cross members. Newer plastic tanks will require a resiliant sponge pad on these cross pieces due to elasticity of plastic. Tanks stretch slightly under pressure & return to original size with no pressure inside. Cross pieces in fuselage may be relocated to suit different tanks.

A tab on rudder may be found helpful in making flight adjustments.

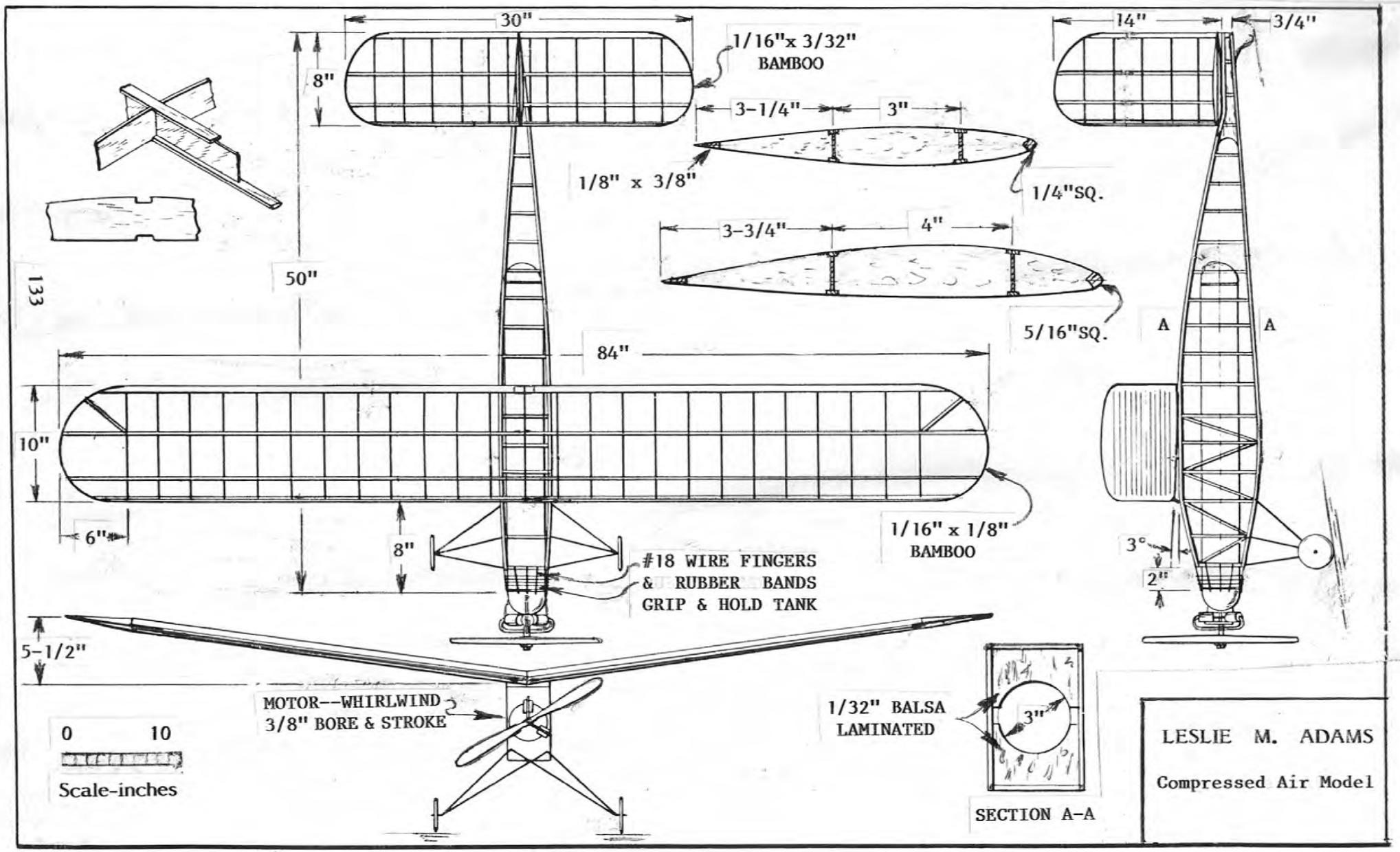
Remember that SAM rules limit pressure for COMPRESSED AIR models to 150 psi!

Compressed Air Model



LESLIE ADAMS' COMPRESSED AIR MODEL - 1935.

Leslie Adams' interest in aviation & model aircraft came naturally because his father was an "advance man" for a barnstorming pilot of a Ford Tri-motor "tin-goose". Leslie worked at the Peru Model Airplane Shop while his father was on tour with Harold Johnson, who looped, barrel rolled & stunted Tri-motors.
Leslie was thrilled at Casmir Leja's compressed air models performance, so he decided to build a compressed air model of his own design. Apparently Leslie's best time for this model was about 190 seconds. Average flight-90 seconds.
Adams' neat ship weighed in at 28 ounces without any air pressure in tank. He used a 3 inch diameter by 30 inch long seamless brass tank. This size of tank is no longer available. However, with a minor widening of model's fuselage to accept 4-1/4 inch diameter plastic tanks described elsewhere, you would have a lighter ship but with more air capacity. Two 122 cubic inch plastic tanks give 244 cubic inches volume compared with 205 cubic inches for the tank Adams used. Adams' brass tank weighed 7-1/4 ounces. Two plastic tanks are a light 4-1/8 ounces. This 3 ounce saving in weight is more than adequate to permit installation of light rudder-only, R.C. such as Cannon. Adam s' big 10 by 84 inch wing would make this ship a good C.A. R.C. model for ambitious experimenters!
As explained elsewhere, C.A. is similar to rubber models. First burst of power, whether rubber or compressed air, should get model up fast so that model will cruise at good elevation for longer flights. Adam s' ship may get up higher & cruise longer if a slightly smaller diameter & lower pitch propeller is tried. A 14inch diameter with 18 inch pitch is suggested for trial whether for free flight or radio control. Adams used 15" diameter x 20" pitch for his propeller.
Adams' model is easy to build & is full of good ideas for the beginner as well as experts. Adams was a member of U.S. Wakefield team at one time. He built this model following construction methods & strength of parts similar to his Wake models.
Adams constructed his wing starting with center rib & bottom cap strips. Then he cemented webs-rib-webs-etc. to end rib. Then top cap strip was added. With all joints securely cemented, the wing is quite sturdy. Completed wing is held to fuselage in usual manner with rubber bands. Balance was obtained by axial position adjustment of tank & motor assembly, held by 12-#18 wires & rubber bands.
Rudder & horizontal stabilizer use same rib section. Rib spacing in both is 2-1/2". Construction is same as wing. Wing ribs are spaced 3".
Fuselage longerons are 3/16" square. Angle braces & uprights forward of angle braces are 3/16" square. Uprights & cross pieces to rear are 1/8" square. All fuselage uprights are spaced 2-1/2".
Landing gear is 1/16" steel spring wire with 3" laminated balsa wheels made of three 1/8" plies cemented cross grain at 120°. Wheel tread spacing is 16".
All ribs are cut from 1/16" balsa. Lightening holes may be added if desired.
Grain of wing spar web members should be vertical or at 45° as opposed to being horizontal in order to better deal with "horizontal shear" forces.
Note that at "Section A-A", tank is supported by 1/32" balsa double thickness which is laminated cross grain. Hole in this bulkhead should fit tank so that tank can be slid for balance.
Frank Zaic's 1935-1936 Year Book included Leslie Adams' C.A. model. That plan indicates that Adams also flew this model with a gas engine alternately.


30"
8"
1/16"x 3/32"
BAMBOO
3-1/4"
3"
1/8" x 3/8"
1/4"SQ.
3-3/4"
4"
5/16"SQ.
50"
133
84"
10"
6"
8"
1/16" x 1/8"
BAMBOO
#18 WIRE FINGERS
& RUBBER BANDS
GRIP & HOLD TANK
5-1/2"
MOTOR--WHIRLWIND
3/8" BORE & STROKE
0 10
Scale-inches
14"
3/4"
A
A
3°
2"
1/32" BALSA
LAMINATED
3"
SECTION A-A
LESLIE M. ADAMS
Compressed Air Model

Tom Crompton's Fun Machine, the "Tadpole".

Mr. Crompton has used this model for 15 years as a test bed flier to try out different COMPRESSED AIR motors. With motors of the Hoosier Whirlwind type, flight times range from 60 to 90 seconds. It is his "fun flier" too.

This model is about as simple in construction as it is possible to design. It could be made in an evening or two. I think that it is a very sturdy model, perhaps too sturdy in a few places. But who can argue with 15 years durability!

If you can make a two can tank which will test safely to a higher pressure than you will use for flying, you have one of the more important parts of the model.

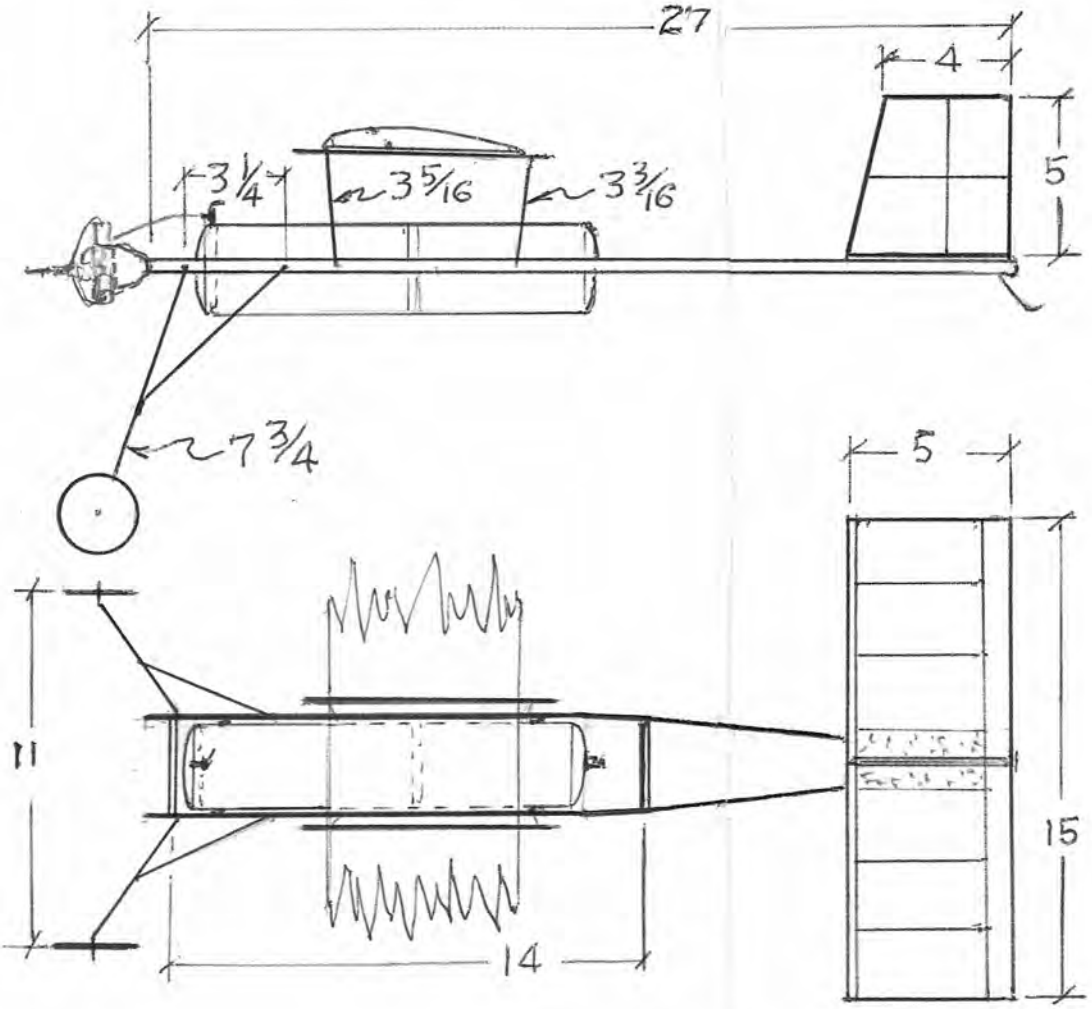
The landing gear can be wire or bamboo. Use doubler pieces at the center to make the junction of the two halves of the wing amply strong. The small wing beams are 1/8" square. The rudder pieces are also 1/8" square. Tom made the trailing edges of the wing & elevator from 1/4" x 1" wedge shaped balsa. The entering edge of the elevator is 1/4" square rounded in front. The entering edge of the wing is 5/16" x 3/8" shaped to blend with the rib curve. All surfaces are covered with tissue & doped.

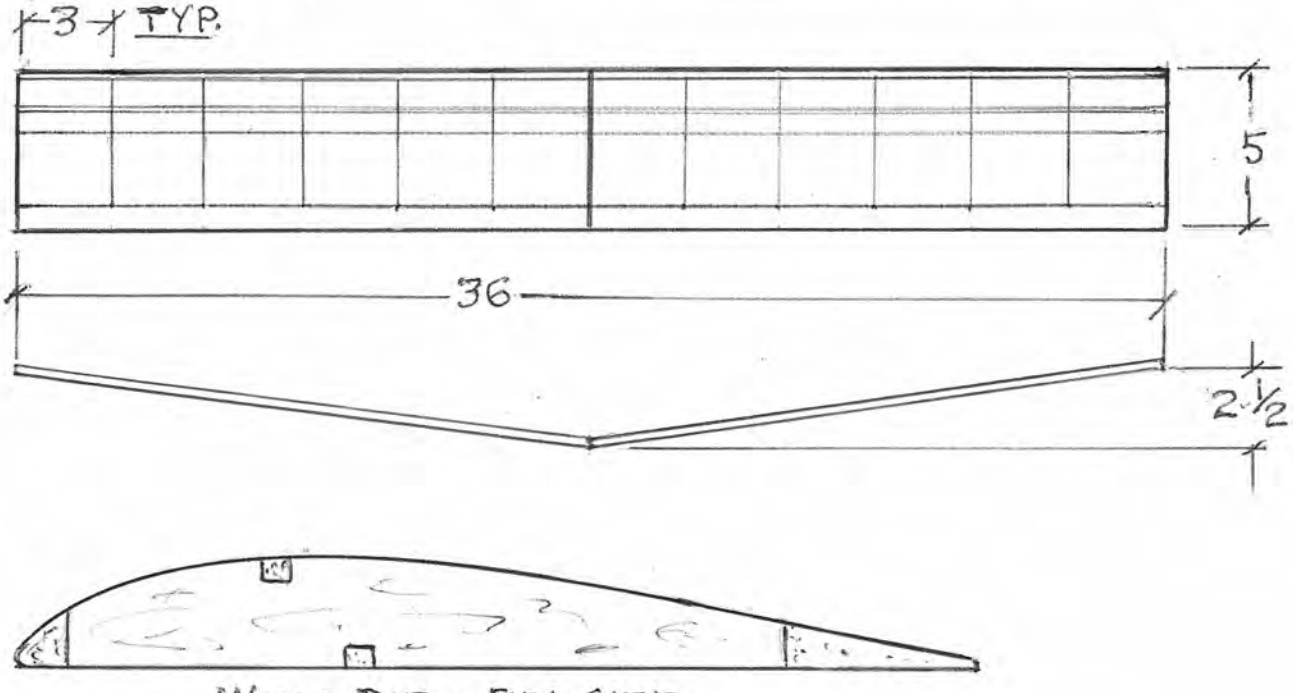
The fuselage longerons are 1/8" x 3/8" hard balsa. For instructions regarding the making of the tank, see the section on how to make beverage can tanks. Space the longerons about 1/4" farther apart than the diameter of the tank. The diameters of the aluminum beverage can tanks do vary. Crompton used sponge material to wedge the tank snugly between the fuselage longerons.

The different motors which Tom tried on this model were attached to a brass tube frame -not shown- in front of the two fuselage longerons. Make the most simple support for whatever engine you wish to use. Connect it to the tank at the throttle valve. Make thrust tests using one of the methods described in this book-or one of your own methods-until you get an initial thrust at full air pressure equal to 1/4 to 1/3 of the total weight of the model. That would be the correct propeller to use for good flights.

The wing is adjustable fore & aft on the "horizontal bars" to attain proper balance.

Perhaps you too can obtain 15 years of fun from the little "Tadpole" by Mr. Crompton. Walt Winberg of Canada has been flying one of Tom's "Tadpole" models for some time.



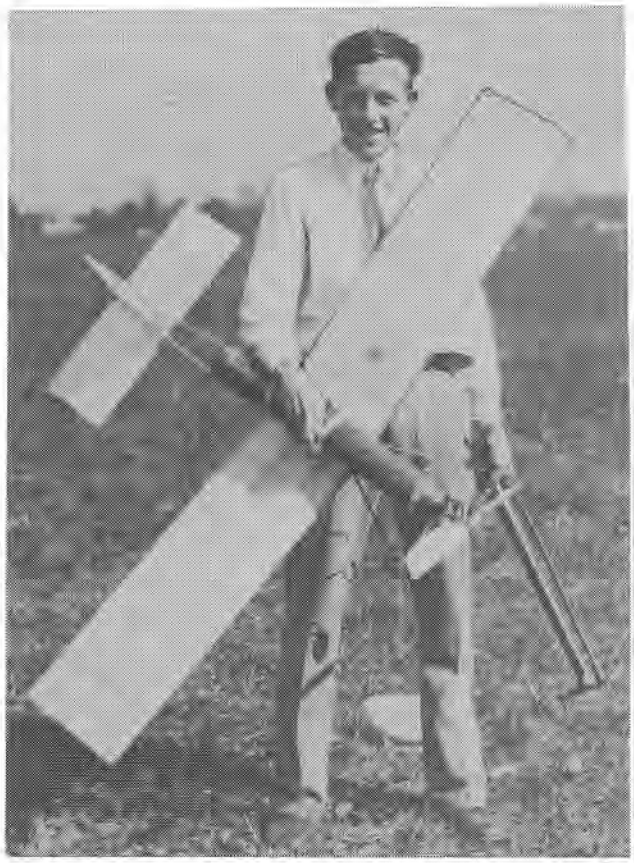


WING RIB - FULL SIZE.

DRAWING BY TOM CROMPTON - ENGLAND

The Jim Noonan "Old Timer Special" COMPRESSED AIR Model.

Jim Noonan is one of the better known experts of the COMPRESSED AIR model clan. He has won the 1st place in 3 SAM COMPRESSED AIR model events with this fine model which he has drawn the plan for you.
Jim used a 3" diameter x 24" long brass tank with a Whirlwind 3 cylinder radial engine for the powerplant. Jim used the old standby foot stirrup pump to pump 80 to 100 psi. by hand for his many flights. (I use an electric pump which can be plugged into the 12 volt cigarette lighter socket in my automobile.)
Jim's model is strong where it needs to be but it is constructed very light where it can be. He used hollow wing spars & sliced ribs from 1/16" balsa in order to attain the lightest possible weight. The total weight of the machine without pressure in the tank is 11 ounces. With a wing area of 578.5 square inches, this calculates out at 2-3/4 ounces per square foot. Jim attributes much of the performance of his fine ship to his propeller. He uses a 13" diameter x 14-1/4" pitch balsa prop carved from a blank 7/8" x 1-1/4" x 13" "toothpicked from 7/8" at 6-1/2" diameter to 7/16" thickness at the tips. You can't argue with 3 wins!
This model was designed in 1984. Since that time, the use of plastic tanks has come into the COMPRESSED AIR model picture. The volume of a 3" diameter x 24" long brass tank is only 2/3 that of a a twin 122 cubic inch tank, yet the brass tank weighs 1-1/2 ounces more than the plastic tank! This machine would look very little different if the fuselage was increased to accomodate the twin plastic tank. The lengths of the two tanks are the same. The C.G. of the two tanks are almost identical, & coincides with the center of lift of the wing. You would not have to be a brave soul to try a plastic twin tank. Just be sure that the tank is tested to some higher pressure than you will fly with.
Then with all this extra air & lighter weight, you really have a new problem which Jim did not have. The ship would really require a dethermalizer to pop up the tail before you lose the model! (See separate loose plan #136A.)



The Harley Rich model & pump at the ready. The model is described starting on page 137. Note the simple lines which the ship has. The large wide blades or "butter paddles", as they are called, put the area where the work is done.
I knew Harley Rich. He was a very fine modeler & person. Note the pleasant smile on his face. Also look at the small bore on the pump.
Harley worked in the laboratory of the Tennessee Valley Power Authority. His most promising career was cut short by a most horrible phosphorus explosion in the laboratory which took his life.

Harley Rich COMPRESSED AIR Model

This prize winning model took first place at Louisville, Kentucky during the National Playground Association meet in 1929. Harley's design is distinguished by its very light weight & simple construction. Relative novices in building & flying models will find this Rich COMPRESSED AIR model to be a most easy & enjoyable project to build & fly.

Because this model is flown by COMPRESSED AIR motor, the AMLA (the American Boy Magazine Airplane Model League of America), called this ship a graduate course in model building.

A Hoosier Whirlwind 3 cylinder radial engine mounted on a 3" diameter by 24" long seamless brass tank, wire wound, powered Rich's model. We have since learned that steel wire wrapping on brass tanks does not do what it was intended to do. This wire added considerable extra & useless weight to the tank.

The crutch or cradle frame allows the use of other tanks. Bob Knutson flew his Rich model with a 3-1/2" diameter by 24" long tank for 55 seconds on his very first flight. The new light weight plastic air tanks will work well with the Rich model & should make much greater duration possible due to their 50% less weight than the brass tanks.

Gather all of the materials of construction in the following list & study the plans carefully before beginning to cut balsa.

Bill of Material

2 pieces	balsa	1/32" x 1" x 40"	for entering edge & false ribs
2 pieces	balsa	1/8" x 1/4" x 40"	for trailing edges of wing & rudder
1 piece	balsa	1/16" x 1/4" x 20"	for trailing edge of stabilizer
1 piece	balsa	1/8" x 1/4" x 20"	for elevator beam
2 pieces	balsa	1/4" square x 20"	for entering edge rudder & stabilizer
2 pieces	balsa	1/8" x 3/8" x 20"	for wing beams, rear
2 pieces	balsa	1/8" x 1/2" x 20"	for wing beams, front
2 pieces	balsa	1/20" x 2" x 40"	for ribs
2 pieces	balsa	3/16" x 1/2" x 40"	for fuselage longerons & cross pieces
1 piece	balsa	1-1/2" x 2" x 14"	for propeller
5 pieces	bamboo	1/16" x 1/4" x 11"	for landing gear
1 piece	music wire	12" -#12 (.029")	for wing clips
3 sheets	tissue	21" x 31"	for wing surfaces
2 pieces	tubing	3/32" O.D.-brass	for axles -1-1/2" long
2	wheels	2" to 2-1/2" dia.	light weight

1 power plant - 3 cylinder Whirlwind (or equally powerful motor) with tank.
cement, dopes & thinners as required.
masking tape for attaching powerplant to fuselage.

The entering edge of the wing is 1/32" balsa, wet & formed around a shaped piece of scrap material until dry. Cut lightening holes in all ribs except wing tip ribs. Pieces of K & S brass tube, sharpened, are quite handy for this purpose.

Weight of wing should be about 1.50 ounce.

Rudder & elevator weight is about .25 ounce.

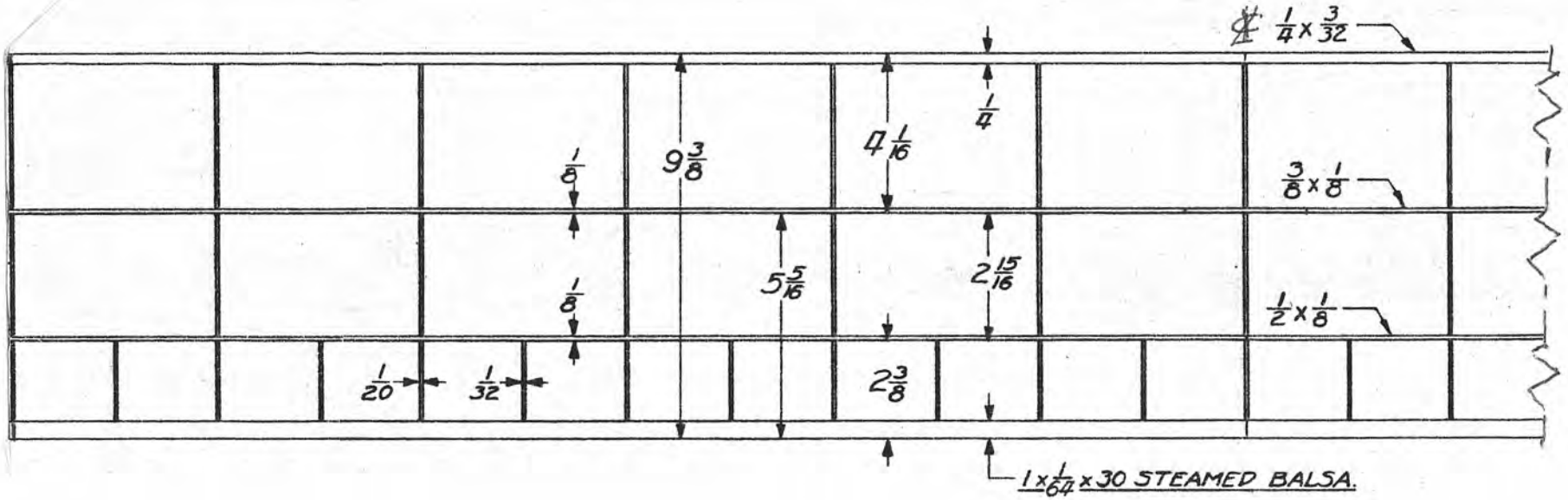
Fuselage with landing gear weight is approximately 2.10 ounces.

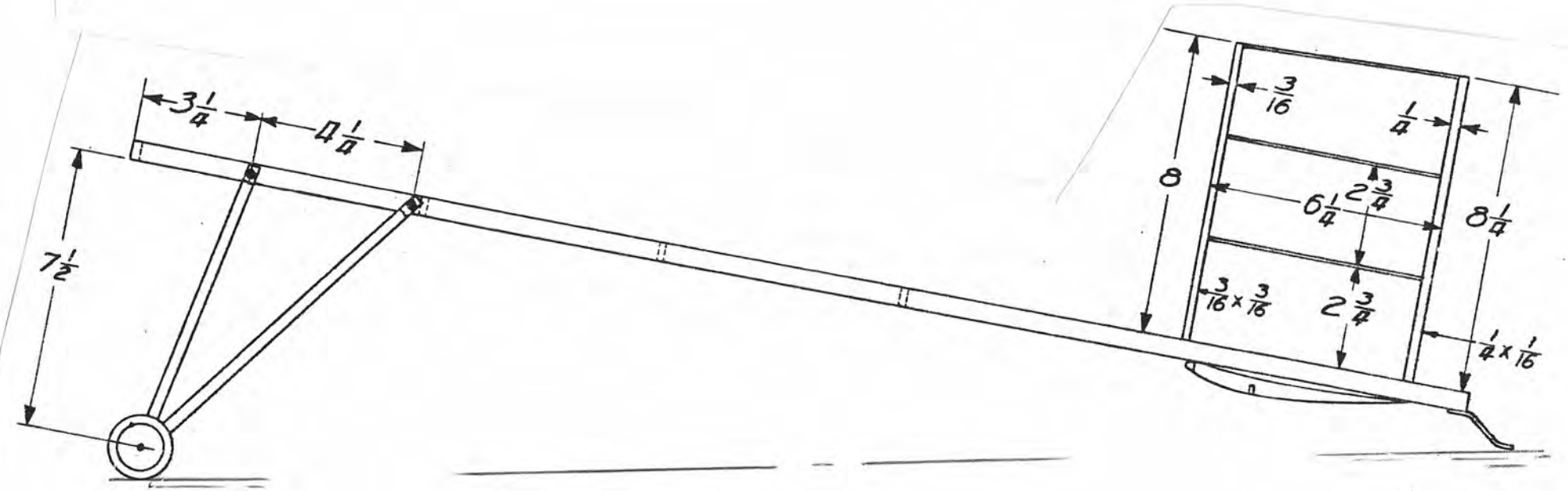
Propeller weight is approximately .25 ounce

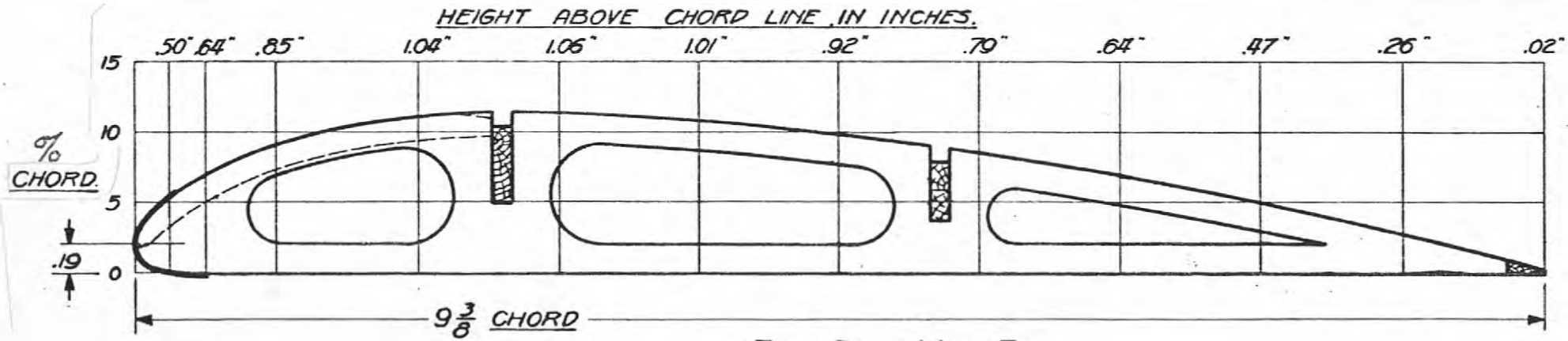
Total weight less power plant is therefore about 4.10 ounces-very light for a big machine!

For a 1929 ship, this Rich model was well ahead of its time. With a neutral or lifting tail rather than Rich's negative tail & with light plastic tank, duration could be much improved.

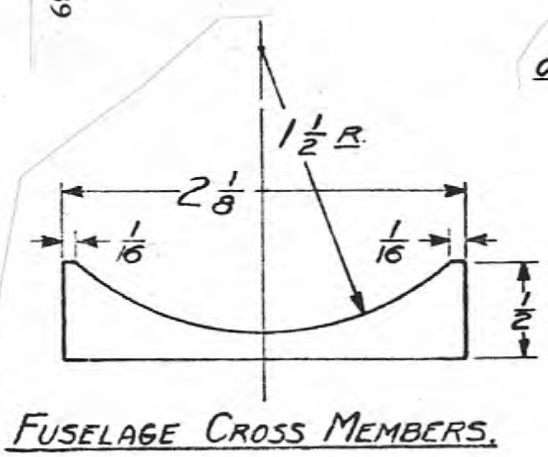
Test glide the model when the wind is not blowing too hard! A preferred method is to use a weight equal to the weight of the powerplant with propeller, taped securely at an inch ahead of where the center of the tank would be. This saves possible harm to the powerplant during initial testing . When proper wing setting for a long flat glide is found, locate the center of gravity of the powerplant at the location of the weight & after removing the weight, tape the powerplant in place with masking tape at 3 places. Model should glide the same as with the weight. Try a flight with about 50 pounds pressure in the tank. Tab may be used on the rudder .


1/4 x 3/32
1/4
1/8
9 3/8
4 1/16
3/8 x 1/8
1/8
5 5/16
2 15/16
1/2 x 1/8
1/20
1/32
2 3/8
1 x 1/64 x 30 STEAMED BALSA.

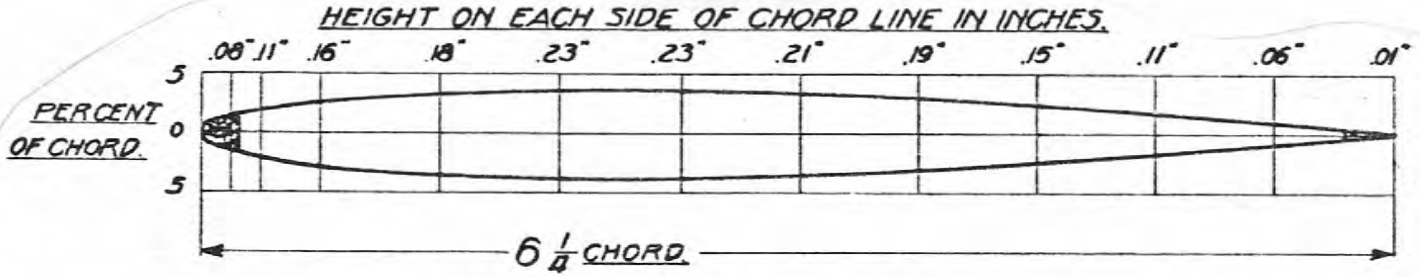

3 1/4
4 1/4
7 1/2
8
3/16
1/4
2 3/4
6 1/4
8 1/4
3/16 x 3/16
2 3/4
1/4 x 1/16



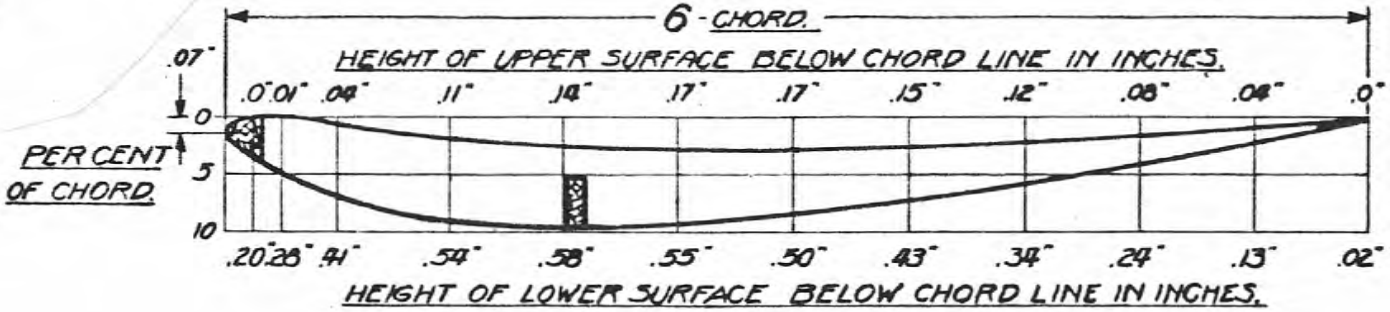
FULL SIZE WING RIB.



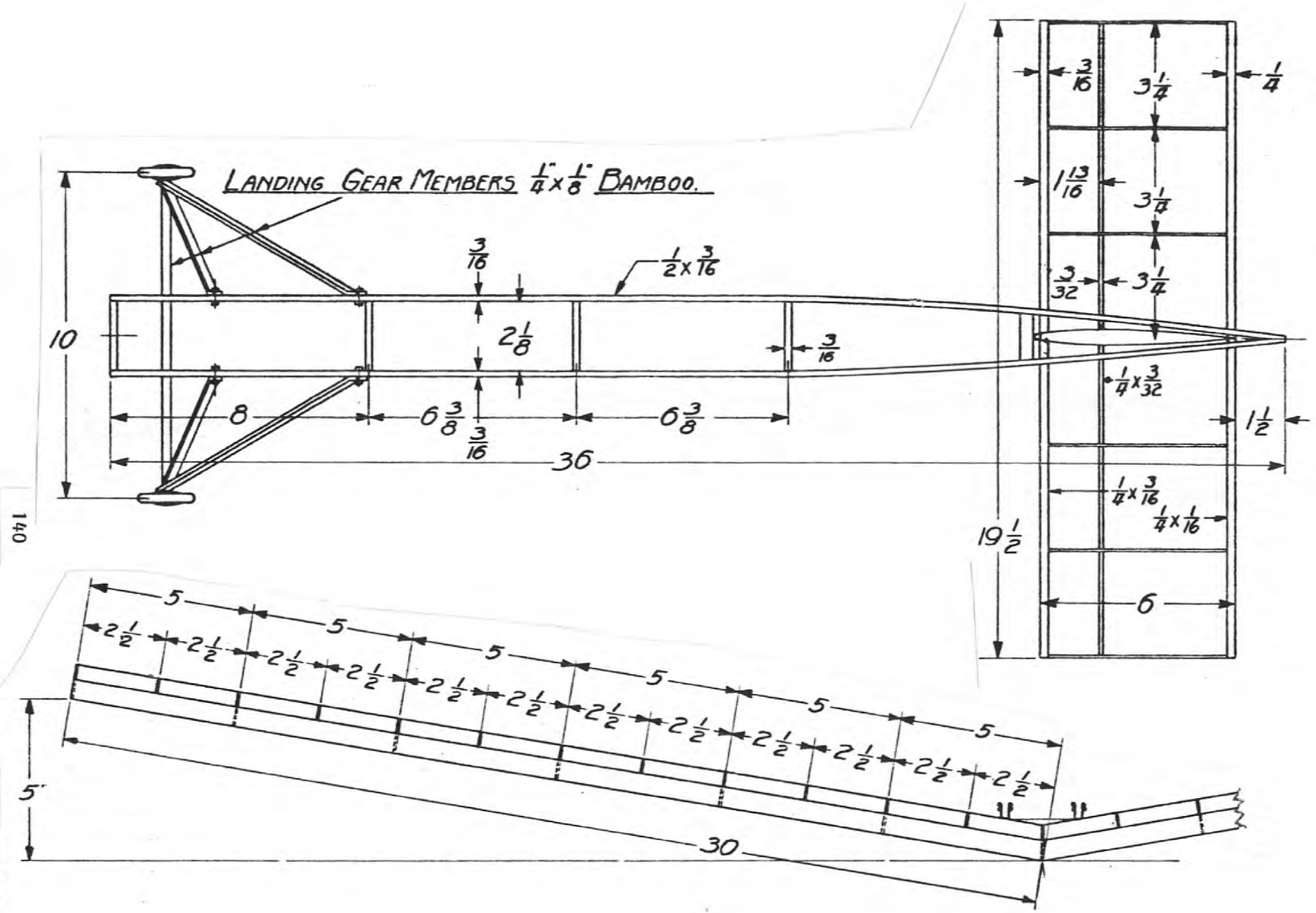
FUSELAGE CROSS MEMBERS.



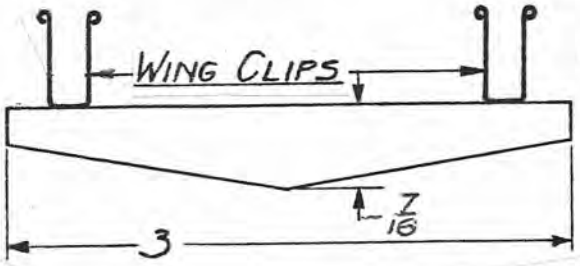
FULL SIZE RUDDER RIB.



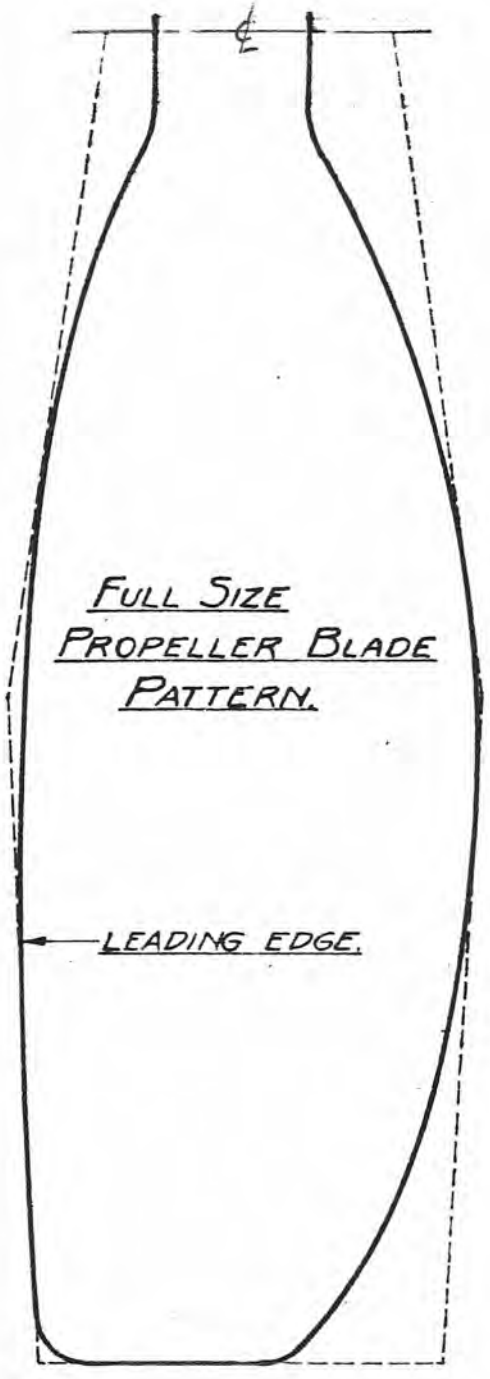
FULL SIZE STABILIZER RIB.


LANDING GEAR MEMBERS 1/4" x 1/8" BAMBOO.
3/16
1/2 x 3/16
10
2 1/8
3/16
8
6 3/8
3/16
6 3/8
36
3/16
3 1/4
1/4
1 13/16
3 1/4
3/32
3 1/4
1/4 x 3/32
1 1/2
1/4 x 3/16
1/4 x 1/16
19 1/2
6
5
2 1/2
5'
30

140

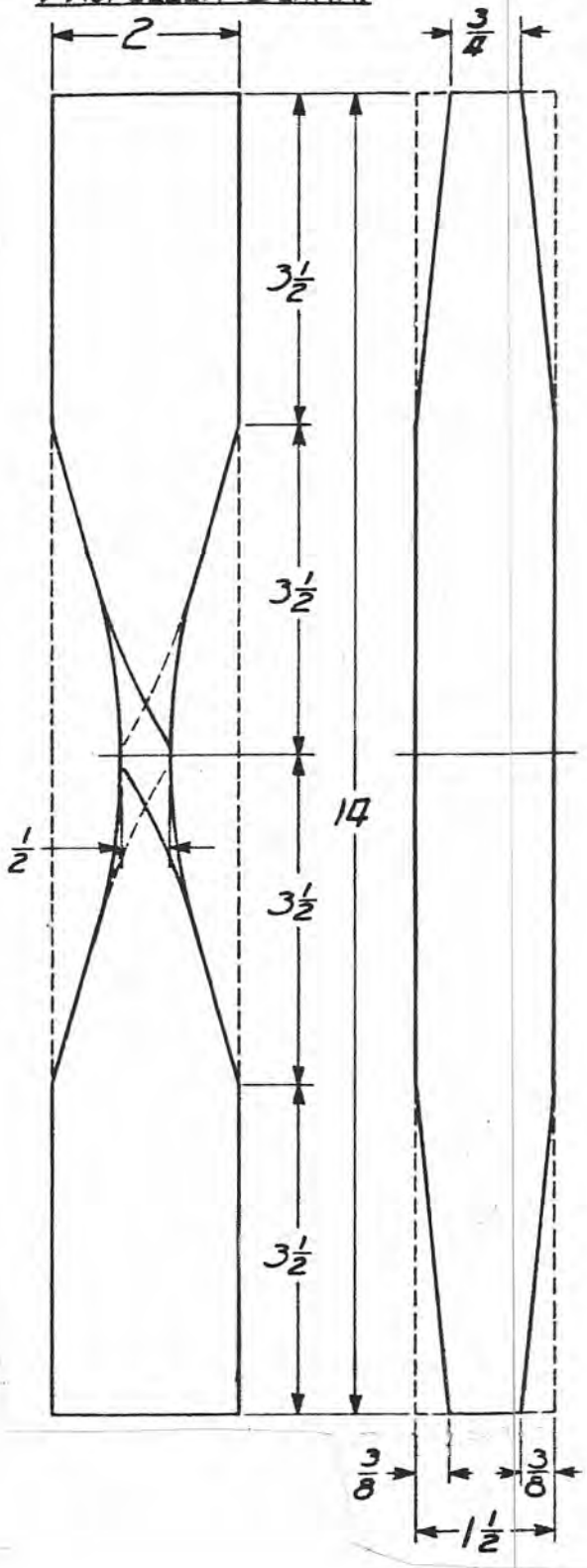


FULL SIZE
INCIDENCE BLOCK FOR
REAR WING BEAM.



FULL SIZE
PROPELLER BLADE
PATTERN.

PROPELLER BLANK.



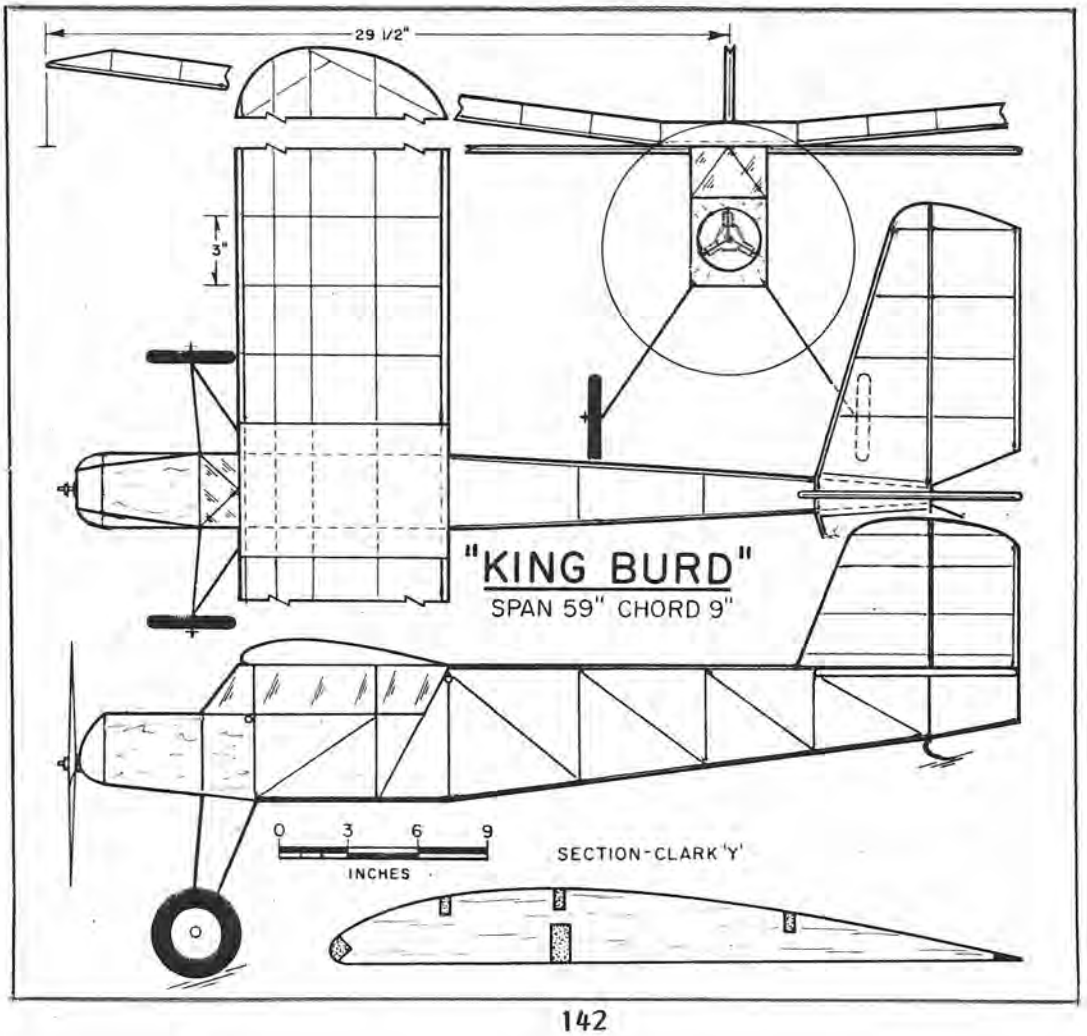
"Long live the KING ----------BURD!"

It was back in 1935 when George Austerman designed & flew a gas model at Logan Field, Baltimore, Maryland. Austerman & the hobby firm of Kramer Brothers kitted this model & named it "KING BURD". Because not many modelers could afford gas engines in those 'lean' years, their advertising suggested that rubber power could be used until an engine was on hand. This was Danny Sheeld's dilemma when he was a little fellow of 13 years. Danny says that he could not afford an engine then. However he liked this KING-BURD so much that when he was a little bigger, he also kitted some of his beloved KING-BURDS. It was only natural for Danny to pattern a COMPRESSED AIR model after KING-BURD. Danny reasoned that if it would fly on rubber & with a gas engine, why not on air? Danny did reduce sizes of balsa slightly & adjust fuselage to accept his Whirlwind powerplant. With this ship, Danny won Tim Banaszak's coveted COMPRESSED AIR Trophy in 1980 with a 187 second total time. On one flight, his KING-BURD flew across Wright Field & over a high fence into a housing area. Fortunately some one found it & returned it so that Danny was able to complete his quota of flights.

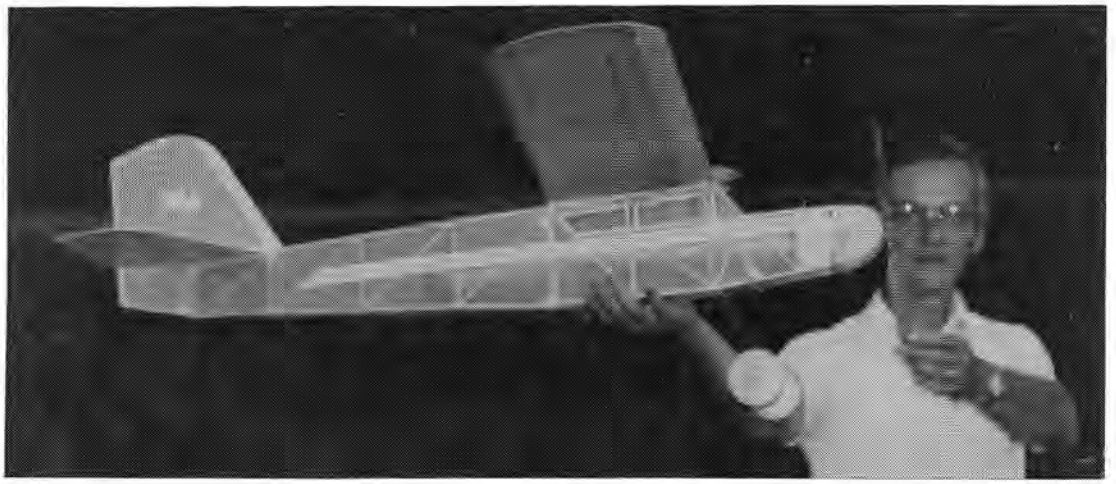
Danny was flying his COMPRESSED AIR KING-BURD at Westover Air Base & made a very long flight at another SAM meet. Tom McCoy, after seeing this beautiful model fly with nothing but a tank full of air, fell in love with KING-BURD also. McCoy built several of these ships. His first one weighed 16 ounces complete. McCoy used a folding propeller to minimize damage from propeller striking anything. He found that balance was helped if the nose was 2-3/4"' longer. Then he proceeded to enclose his Whirlwind motor with a neat cowling since air motors do not need cooling! Tom won Banaszak's Trophy in 1983 & again in 1984. Tom did not enter in 1985 but he placed in 1986. McCoy made a second model which weighed complete only 13 ounces. McCoy states that he gets best results flying his King-Burds with 2° right thrust. Tabs on rudder & left wing assist in right-right flights. With lighter weight plastic tanks which reduce total weight considerably, even longer flights than those made by Sheelds & McCoy should result. Minor modifications to fuselage for larger diameter tank would be relatively simple.

Who knows, KING-BURD may become as popular as Hughes Hobart's COMPRESSED AIR model.

A hint from Tom's book: test fly a model to learn all of its traits & maximum capabilities!

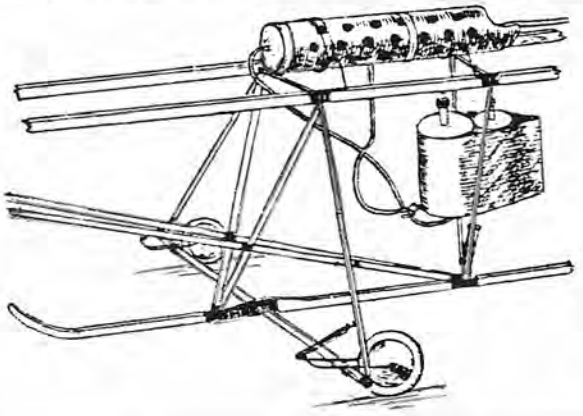


Actually, Tom called his later ship with the long enclosed nose a "King-Air".



Early Pavely Steam Power Plant for the Olympia.

I came across this little article about a steam power plant for models which Mr. D. A. Pavely built, in the May 29, 1914 issue of the English magazine, "Flight," page 584. As you can see, Pavely built not only rubber & COMPRESSED AIR models but he also built steamers. The very early power plants were rather elementary as can be seen from the sketch below.



The sketchy details of the model given in the article are as follows: The flash boiler coil was made from a 72 inch length of 3/16" diameter steel tube fitted into a flame confining shroud. The fuel flow to the torch was by pressure, controlled by a needle valve. The water feed was by pressure also, rather than the more common pump method. Pavely used a needle valve here too, in order to attain accurate control.

The fuel & water tanks, shown in the sketch to the right & below the burner, are vertical cylinders enclosed within a thin aluminum streamlined shroud. The water supply tank has a valve at the outlet & a filler cap with a cycle type air valve on top for pressurizing.

The engine, not pictured, was one of Pavely's conventional 3 cylinder rotary types. The bore was 7/16" & the stroke was 9/16". It drove a 16" diameter propeller with a 20" pitch.

The weight of all of the power plant, fuselage with landing gear, wheels etc. but without the wings, was 38 ounces.

An interesting feature was the manner in which Pavely mounted the 3-1/2" diameter disc wheels. The "U" shaped wire yoke was pivoted around the cross axle & a band of rubber provided a very soft suspension for the model.

The sketchy details did not provide any data other than the above. I would have to assume that the model was a pusher with the engine & the wing on the right hand side & the elevator to the left.

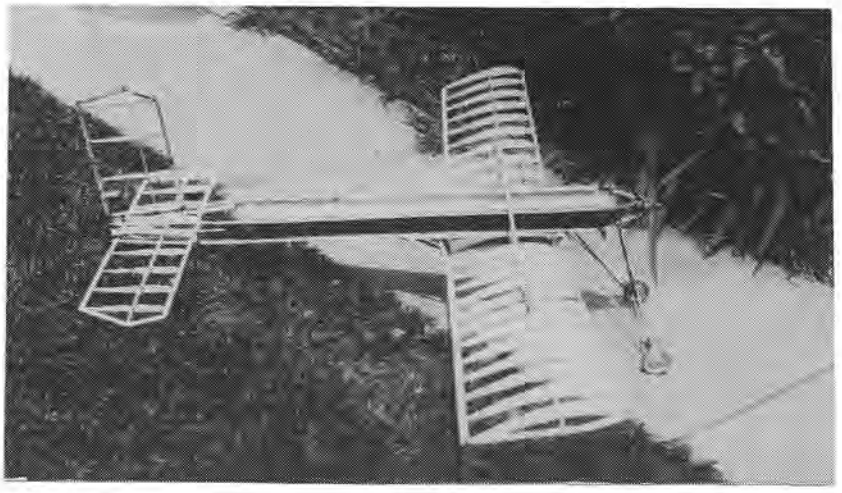
Obviously this power plant was not the last word in efficient performance capability. The pressure feed power plants in which the steam pressure is used to maintain the water pressure at a steady state would be a more desireable arrangement. As shown on another steam plant, an oiling means is almost a necessity. If Pavely had an oil feed, it was not described.

The Carl V. Carlson COMPRESSED AIR Model Aircraft.

The Chicago model aircraft experimenters kept abreast of the model news around the world by following the model aircraft pages in world wide aviation magazines which were sold at the famous P.O.News, a small shop in Chicago's loop. They learned that COMPRESSED AIR models were winning model contests in England competing against all other types of models. Soon the members of the Illinois Model Aero Club were building & flying COMPRESSED AIR models. When the Chicago Daily News ran a model airplane contest to select a team to be sent to the Playground Association Nationals in Louisville, Kentucky, Carl Carlson & Edward Miller won the trip with their COMPRESSED AIR models. Then in Louisville, competing with fliers from all over the country, Carlson won second honors & Miller placed third. The first place was won by Harley Rich whose model plan is shown elsewhere in this book. All flights were R.O.G. & all three used Hoosier Whirlwind three cylinder radial engines & the seamless brass tanks which were the best available at that time.

The next year at the Chicago National Air Races, Miller topped the field. Carlson ended up in second place while a chap named Svitenky came in third. As usual, all three of these fliers had made better flights than were made at the contest. Svitenky had made a number of flights in the 70 & 80 second range. Plans are unavailable for Miller's & Svetenky's planes, but fortunately Carlson has furnished a plan of his fine model along with a picture.

The seamless brass tanks are no longer available but the new plastic tanks which are 50% lighter should make Carlson's model take off & fly even better than he was able to fly his ship.



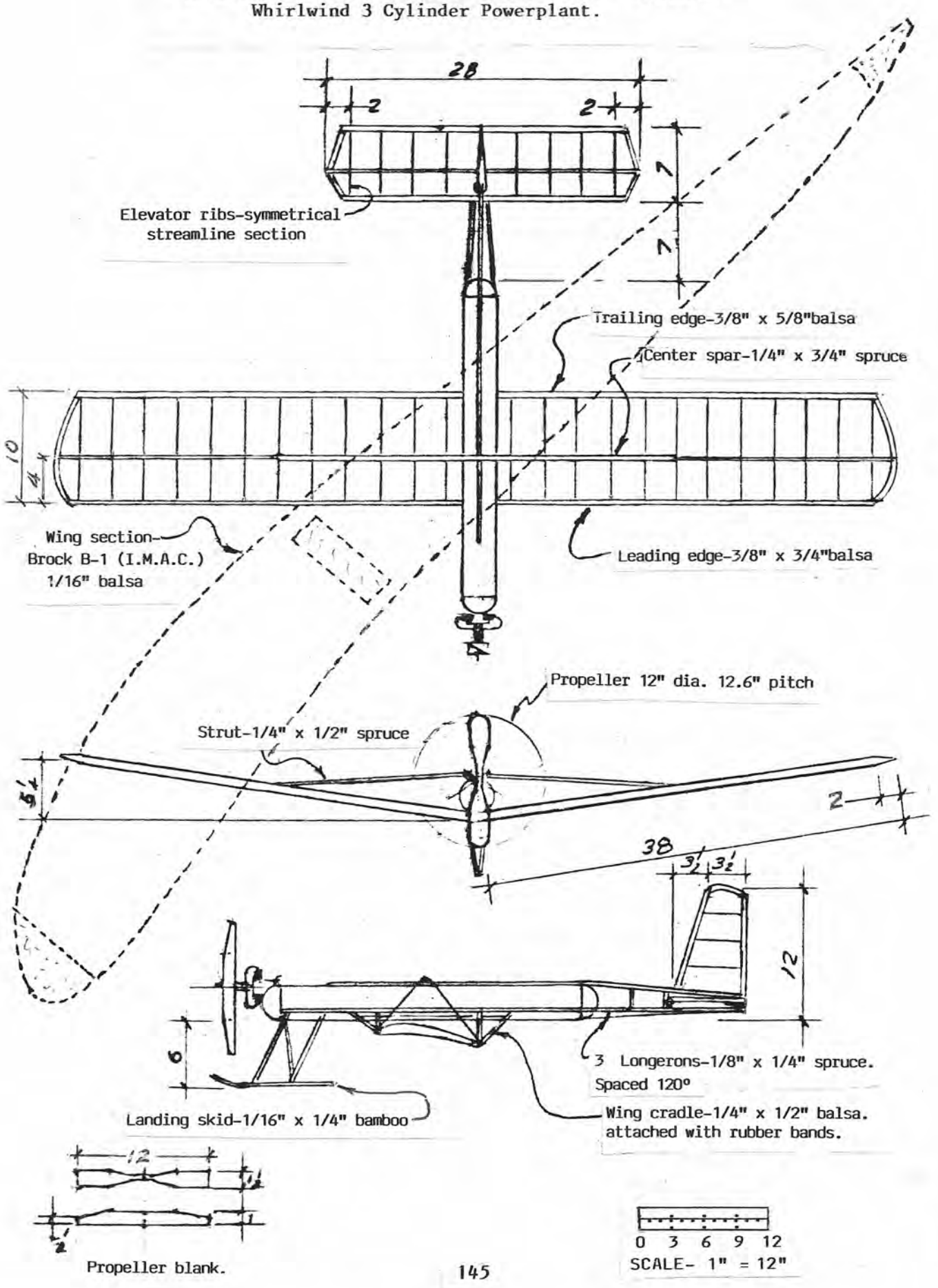
Carlson's COMPRESSED AIR model before it was covered. The landing gear placement is well forward in order that the propeller & motor are protected and to balance the tail. The wheels on this model were later replaced with a central skid. In gliding tests, the wing had to be moved to the rear as shown below for balance.



This picture depicts Carlson pumping air into the container in preparation for a flight. He is using a foot stirrup hand pump. Note that the pump plunger handle is held close to the legs & that the arms are straightened at the time when weight of the body becomes necessary to finish the stroke. Electric pumps are available for doing this chore more easily.

CARLSON 1929 COMPRESSED AIR MODEL.

Whirlwind 3 Cylinder Powerplant.



HUGHES HOBART RECORD BREAKING COMPRESSED AIR MODEL AIRPLANE

In the summer of 1932 Hughes Hobart designed, built & tested a COMPRESSED AIR POWERED model airplane with help from his summer camp instructor, Mr Doyal. This model looked like an airplane. It flew like an airplane. Longest test flight at summer camp was 225 seconds & about 1 mile distance.

Hobart flew his model in California State Championship Model Contest on 3rd of September 1932. Hobart won easily over 102 contestants. Arrangements were made with 3 officials to time an attempt to break 70 seconds English world record of D. A. Pavely on next day. Site was at a larger field, airport of Sacramento, California, since State Fair grounds were too small. Record for R.O.G. was officially broken with a flight of 146.8 seconds. Hand launched record of 212.2 seconds was established also. Both flights traveled over half of a mile.

Long after war years, Tim Banaszak offered a trophy for compressed air models in connection with SAM Champs. Hobart replica models have been winning this Banaszak Trophy quite frequently. They are light in weight. They take off & fly well with good stability.

Some construction details to supplement drawing follow. A Hoosier Whirlwind motor & a 3" diameter by 30" long seamless tank was power plant. Wing had a curved dihedral which was steamed in. Wing tips were swept back 4", measured at last rib. Landing gear was well forward in order to better protect propeller. Note that landing gear was attached to tank rather than fuselage thus avoiding having to make fuselage strong enough to absorb landing shocks.

Rudder & horizontal stabilizer are each adjustable by opposed strings from surface to fuselage. However once adjusted, changes are seldom needed. Hobart used a 1" diameter tail wheel in a wire yoke to ease take-off & landing.

Rudder & elevator tips & trailing edges were aluminum rod. However 1/16" square bamboo would do as well. Wing tips were 3/32" square bamboo.

Wing span measured flat was 72". A single hollow spar 3/8" wide by 5/8" deep with walls 1/16" thick made wing very strong yet quite light weight.

Fine balance for flying is made by axial adjustment of motor-tank-landing gear unit secured with rubber bands to fuselage. Proper balance is a very flat glide without stalling. Since thrust line is low, Hobart had to use down-thrust to prevent stall under power. Hobart adjusted ship to circle against torque.

Since seamless tanks of size used by Hobart are no longer available, minor changes in fuselage section to fit other tank sizes should make this Hughes Hobart model a strong competitor in future COMPRESSED AIR MODEL events.

Plastic tanks with landing gear attached to tank should make this model fly even better than original because plastic tanks are much lighter than brass tanks.

Pitch figure for propeller shown on drawing is incorrect. Calculated geometrical pitch is 14.3", not 11" as on drawing.

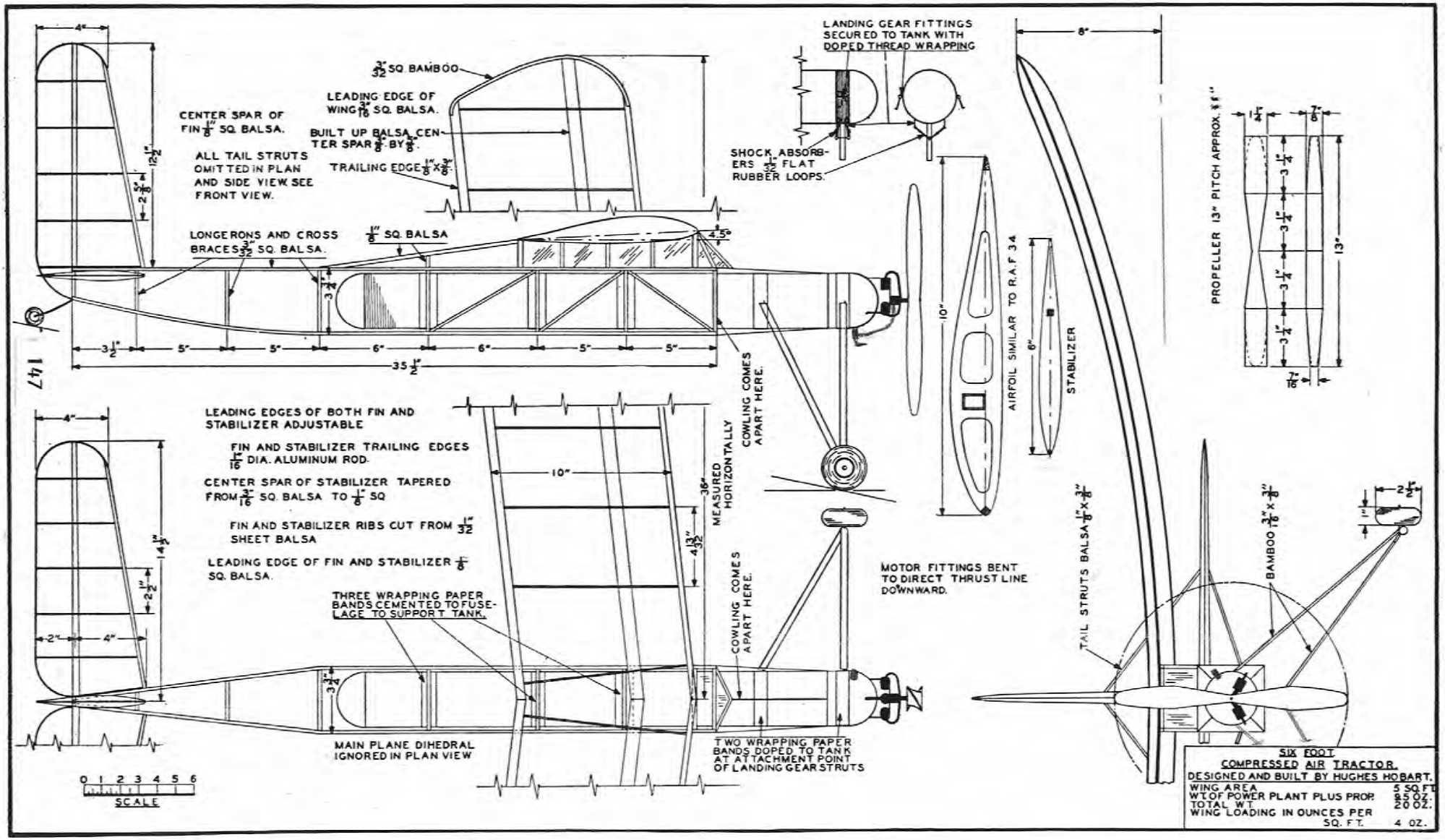
Central landing gear struts in front view are attached to tank with rubber bands & act as shock absorbers by resisting spreading of wheels.

Brass is not sufficiently elastic to affect wrapping paper bands used on Hobart's tank. However plastic tanks have more "give" or elasticity under pressure than brass. Therefore support other than from neck ring should be padded sufficiently with sponge material.

With a wing area of 5 square feet & 20 ounce total weight, wing loading was 4 ounces per square foot. Weight of power plant including propeller was 9.5 ounces.

Hobart's flights were high enough to have caught thermals. Fortunately he was able to retrieve his model after each flight. Dethermalizers are more or less standard equipment on present day rubber models. The author suggests that a dethermalizer be incorporated in Hughes Hobart replica models for obvious reasons! A few compressed air models have been lost. A pop-up tail should be rather simple to incorporate in this model & could prevent loss of your compressed air model.

*FOR FULL SIZE PLAN SEE ITEM 10
ON INSIDE OF THE BACK COVER.*



Spielmaker Drone COMPRESSED AIR Model Aircraft.

Karl Spielmaker used to fly COMPRESSED AIR with a Hughes Hobart ship. He wanted to try something different, which had some scale effect to it. Since Drones are expendable, they are built as simply & economically as possible. This was the sort of ship that Karl was looking for so he selected the WW-2 Drone OQ2A for his project.

This ship has flown exceptionally well. It has placed high in the SAM COMPRESSED AIR events frequently.

Tim Banaszak, who has flown Hobarts, has come up with a Drone too. It has placed several times in the SAM Nats COMPRESSED AIR event also. This would seem to indicate that the ship is well suited for this event.

You will note the simple square tipped wing panels for ease of construction. The fuselage section changes from square at the nose to a triangular section to the rear of the back landing gear strut.

This simple fuselage could be readily adjusted in cross section to accomodate the more recent plastic tanks for a 50% reduction in unit tank weight. This would result in longer flights, I am sure.

The wing has a span of 58" & a chord of 8-1/2". The center section is 8", flat for convenience in holding the wing to the flat top of the fuselage. The end panels are 25" long & elevated 4" at the tips for stability in flight.

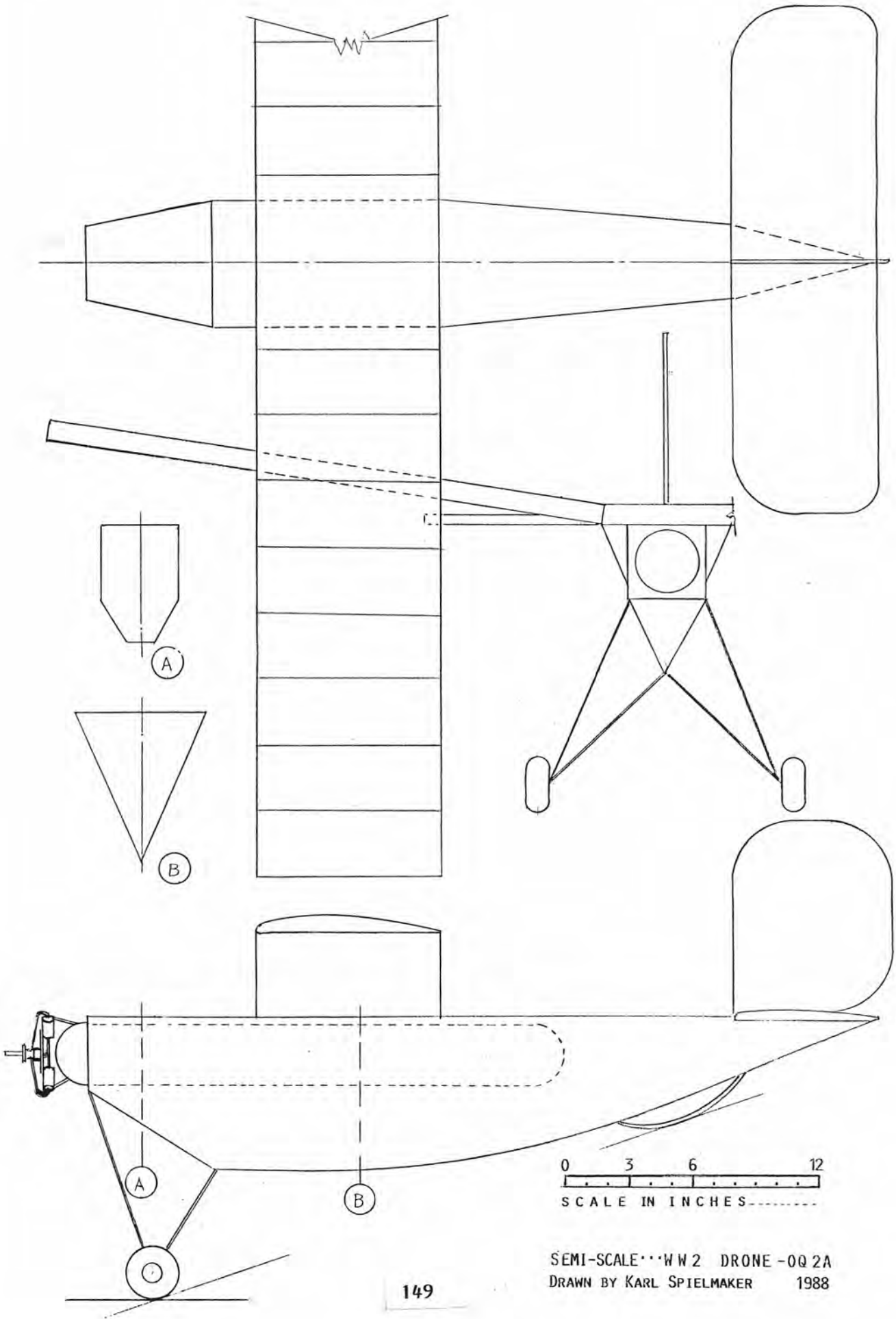
The fuselage is 40" over all. One supporting bulkhead should be provided for the rear of whatever tank you use. This bulkhead should be padded to absorb shocks of landing which usually occur. Karl has decorated the rear underside of the fuselage with a curved bamboo skid.

For flying, you should install a dethermalizer to avoid losing your drone in a bit of "good" air. Never use more air pressure in your tank than you have tested it for with a safety allowance . Do this test behind a safe barrier of suitable type.

Karl used a 13" diameter propeller of 14" pitch to take this drone up into the blue.

All things considered, this is a K.I.S.S. design. The old "Keep It Super Simple" slogan of war production fits it perfectly!

Test the ship well & then open the throttle wide.



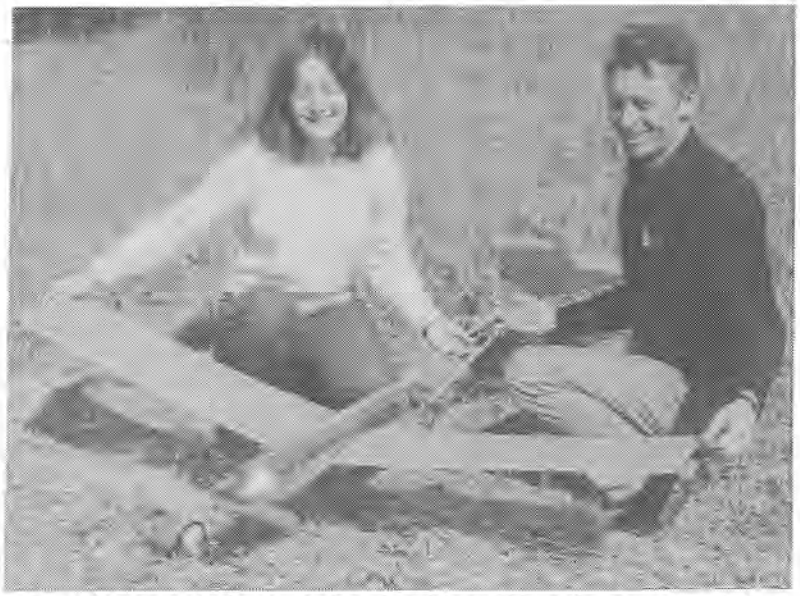
SEMI-SCALE···WW2 DRONE-OQ2A
DRAWN BY KARL SPIELMAKER 1988

John Stott's Camm-McMahon COMPRESSED AIR Model Airplane

Plans for this COMPRESSED AIR MODEL AIRPLANE appeared in "The Design of Model Airplanes" a book by F. J. Camm published in England in 1919. John F. McMahon edited a model airplane section in "Aerial Age" & copied this plan in the issue which was dated February 1920.

Mr. Stott chose this plan to build a COMPRESSED AIR model for competing in CA event at SAM Champs. He was inspired in doing so by Hobart models flown by Dave Stott & Ed Novak. So far John Stott's Camm model has won 1st place 2 different years to hold Banaszak's COMPRESSED AIR Trophy. Best time for total of three official flights was 227 seconds. See tabulation of contest results. With lighter weight plastic tanks now available, this time may soon be exceeded.

John used a Whirlwind 3 cylinder radial COMPRESSED AIR engine. He made his own design of tank using .004 shim brass. Tank was 3-3/4" diameter x 24" long. Cylindrical portion was spiral lap seam about 1/4" wide. Ends were conical with an included angle at apex of cone of approximately 90°. Cones were made sufficiently larger in diameter so that tabs about 1/4" wide & cut 1/4" deep would bend & be soldered at diameter of cylinder. Filler valve was soldered in rear cone & throttle valve in front cone. Weight of tank with valves was 7.5 ounces. Cones were .004" brass shim, same as cylinder. Holding cones & cylinder in true circular positions while soldering tabs, using improvised fixture, makes a good assembly. Camm's tank was 3-1/4" diameter & held approximately 1/3 less air than Stott's tank. Tank was mounted by thin brass straps front & rear to 3/16" x 3/8" spruce fuselage longerons. Straps were soldered to tank. To save weight, longerons to rear of tank were balsa. Stott added a cross brace to stiffen rear of fuselage. One cross piece at front & rear of tank space fuselage longerons equally. Rear balsa longerons were joined at tail. Motor was wired to piece of 1/16" veneer. This in turn was bound to front cross member of fuselage. A plastic tube between throttle valve & motor was wired to complete connection between tank & motor. Fuselage weighed 2-1/4 ounces.



Daughter Linda & John Stott with his Camm model

Landing gear was made with .055" diameter music wire. Stott's balsa wheels were lighter than Camm's rubber tired wheels. Two wire loops form skid at tail.

Rudder & elevator outlines were .036" diameter wire bound with fine wire & soldered to hold shape. Stott used bamboo for elevator entering edge. Tail weight was 1-1/4 ounces.

Camm's wing spars were birch. Stott's spars were spruce & wing ribs were bamboo. Surfaces on Camm's ship were light silk covered, & doped with a thinned varnish. Stott used Japanese tissue covering. King posts for wing bracing were .032" music wire. Bracing wires for straight wing should attach at a point 2/3rds of span out from wing root & not as Camm drawing shows. Camm used .010 music wire & Stott used heavy thread bracing to front & rear spars at center & end ribs. Stott's wing weighed 2-1/4 ounces.

With a landing gear & propeller weighing 1-5/8 ounces, total weight is 14-7/8 ounces.

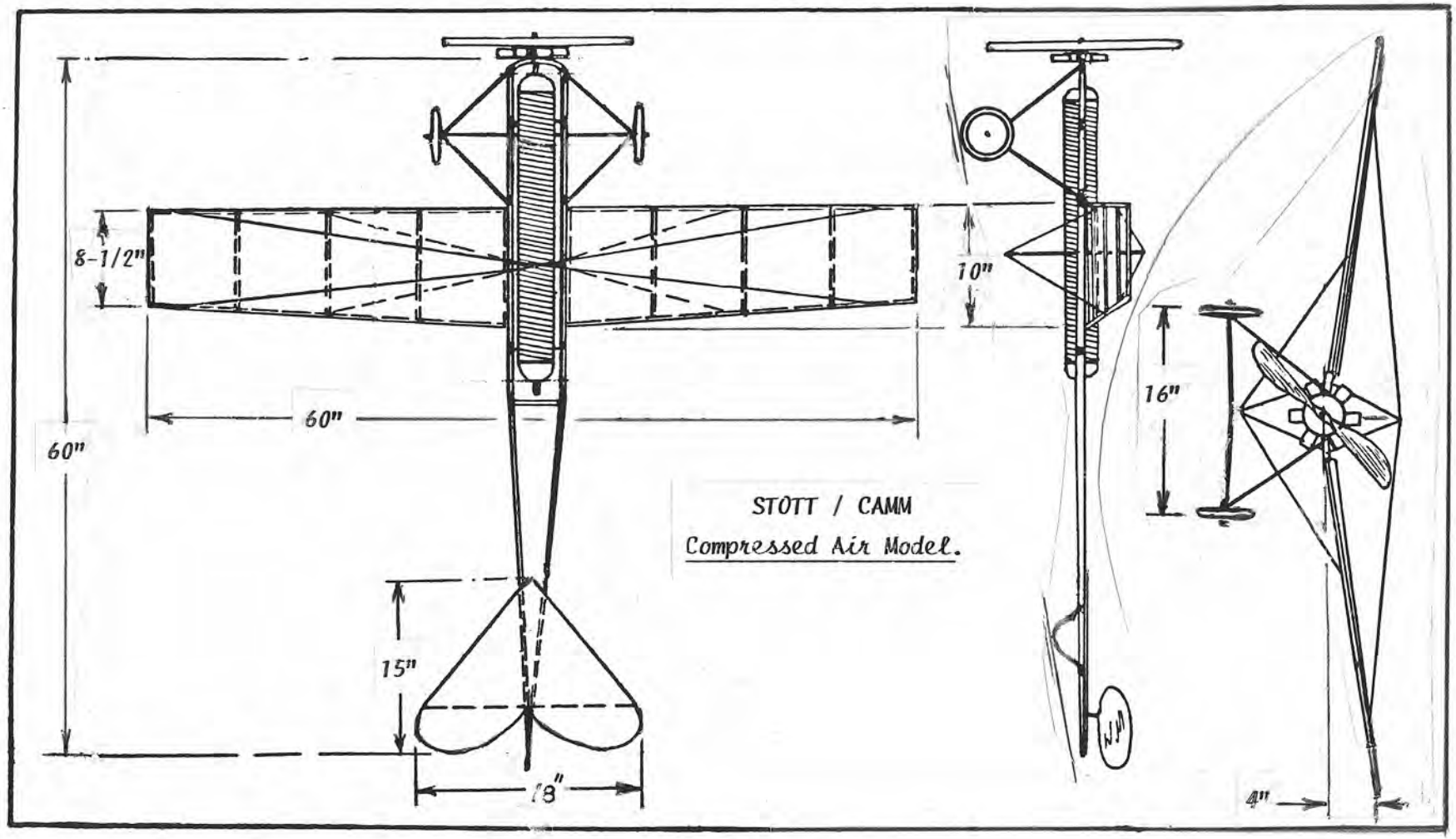
Stott made unofficial but witnessed flights of 4 & 5 minutes at Westover in 1982. He made an official flight of 120 seconds witnessed by English visitors in 1986.

Camm's propeller was carved from a 3/4" x 2" x 16" blank, giving a geometrical pitch of 18.8+". Stott's propeller was balsa.

Stott did not need or use wire winding on his tank, saving considerable weight.

If you build a Stott-Camm model you should consider using a dethermalizer!

THIS MODEL FLIES EXCEPTIONALLY WELL



The Donald Lockwood COMPRESSED AIR Model

Donald Lockwood, a well known Free Flighter from the Illinois Model Aero Club of Chicago, built this model to win the first special event at the Lincoln, Nebraska 1987 Nationals. Lockwood had to Leave lincoln before the event; but he was fortunate in getting an experience COMPRESSED AIR flier to proxy fly his ship, Mr. Carl Carlson. During a very brief lull in the high wind at the free flight site, Carlson was able to get in one 48 second flight while the others either would not fly in the wind or else cracked up.

The power plant was a 3"diameter x 26" long shim brass tank with a Whirlwind 3 cylinder radial motor driving a wide bladed 12" diameter balsa propeller with a pitch of 15" having area outward where it is more efficient. The power plant is held in position in the balsa crutch by a hole in the front strap which straddles the tank filler valve. The crutch longerons are channeled toward the rear. Where the .040" diameter wire rear landing gear wires are fastened to the longerons, it is reinforced with a piece of bamboo epoxied in place. Front 1/16" diameter landing gear wires are bolted to a .015" thick 24st aluminum channel, the same material which is used for the tank straps. The 1/8" diameter steel wires, which are shown full size at the right, plug into 1/8" inside diameter aluminum tubes epoxied to the wing beams. The wires are lightened by grinding each side of the vertical center line to leave a .030" thick vertical section. Full diameter is left at the tip ends & at bends. The perforated item over the top of the tank at the wing is a .006 magnesium sheet held by rubber bands allowing the wing to be adjusted fore & aft for C.G. location. The wing is a lightly constructed version of an A-2 glider. The main spar is 1/8" x 3/8" spruce. The end ribs are 1/16" plywood. All other ribs, "D" shaped entering edge, "Vee" type trailing edge are 1/32" thick 5 pound balsa. The stabilizer is light indoor model construction with 1/16" square sliced ribs, & spars. All covering is light indoor tissue with one coat of very thin dope.

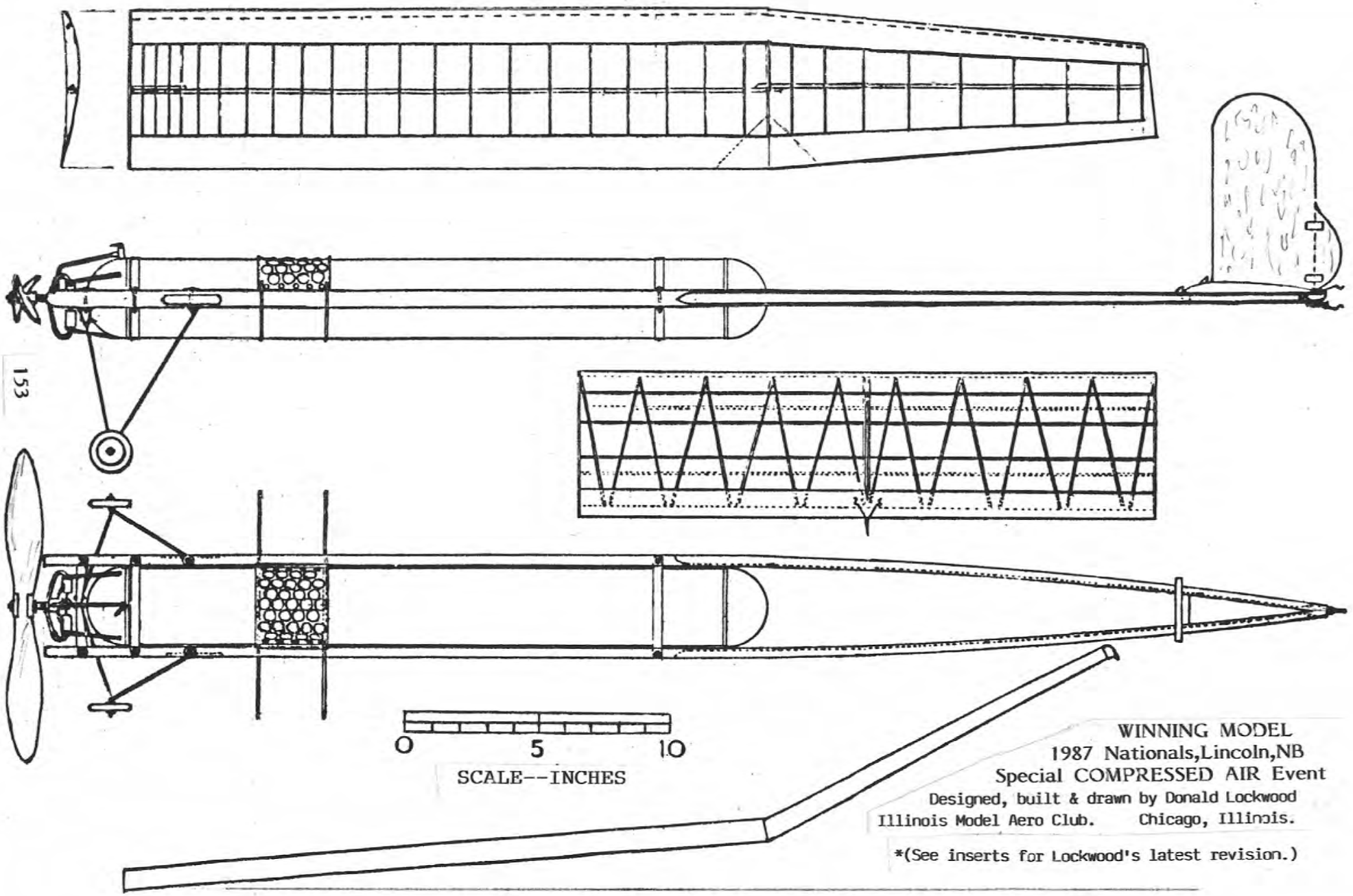


Donald Lockwood & A-2 type COMPRESSED AIR model plane.

A Full size stabilizer rib. 22 required.
B Full size wing rib. 1931 Brock curve #9. 46 full length required & 18 tapered.

The weight of the model less powerplant is under 5 ounces. Be sure to use the dethermalizer, the 2 wires under the rudder, because the model soars very well. The rudder is 1/16" sheet with hinged tab.

Lockwood suggests the use of an aluminum tube outboard shaft extension & support to minimize front end damage in case of a hit on the front end. Use this extension or else reverse the powerplant & use a left hand propeller with the pusher propeller nesting between outrigger tail supports.



0 5 10

SCALE--INCHES

WINNING MODEL
1987 Nationals,Lincoln,NB
Special COMPRESSED AIR Event
Designed, built & drawn by Donald Lockwood
Illinois Model Aero Club. Chicago, Illinois.

*(See inserts for Lockwood's latest revision.)

Models Which Protect Engines in Crashes.

Crash! Bang! "Damn! My best engine -out in front-just got 'creamed'!" For years modelers have been simulating conventional large tractor aircraft with the engines at the very front of the craft. Any time that this type of ship hits any object, the engine may be damaged. In gas engines, mounting lugs are often broken. The fins are chipped & bent frequently. In a few cases, the engines are broken into too many pieces to be of any further use to the modeler. This is a discouraging & expensive situation. Most of the model kits & plans are of conventional tractor craft with the engine out in front where it hits an object first. This is probably the reason why so many damaged engines are offered for swap or sale at swap meets & flea markets. With full size airplanes & R.C. models, the pilots most often have control & can avoid damaging head-on crashes, but not always. In the case of the free flight model, no pilotage is available so bad landings are more frequent. Motor damage is also more frequent. Usually nothing will prevent motor damage in a bad crack-up. A few innovative modelers have approached the problem of minimizing engine crash damage in several different ways!

A folding propeller or a tilting propeller helps considerably to reduce damage to the engine & mounts if the engine does not take a head-on hit. But this is not good enough.

Some have tried a sturdy landing gear with a skid or skids projecting forward in such a manner as to protect the propeller & engine. However the kinetic energy of the whole model is seldom fully absorbed by the landing gear skid & the engine suffers. The use of a canard configuration, with the elevator in front of the wing, & the motor at the rear is of considerable merit if the model does not cart-wheel or change ends in a bad landing. However such a landing becomes almost as damaging to the engine in the cart-wheel when the engine has temporarily assumed a position in front and in the direction of motion, So the canard is not the real solution to the problem. Further, some problems exist with the flying characteristics of a canard which we can do without. Hansen's canard is an example of this type.

What can we do? My personal opinion is that the location of the motor behind the wing & in front of the tail assembly is by far the best solution to the problem. In this arrangement, the engine can be completely shielded even when the model is in an inverted position on the ground. The propeller is between the outriggers which hold the tail. The dihedral of the wing & the rudder height & the landing gear can do wonders in protecting the engine from damage. To this we should include either a folding propeller or a tilting propeller (preferred) to amplify our engine protection. Three model plans are shown which will do a good job of protecting the engine from crash damage.

There is really nothing unusual about this engine location. Numerous full sized ships were arranged this way during World War 1. They were nick-named "gun busses." The invention of the Nelson gear & other devices permitted guns to shoot through the disc swept by the propeller without the bullets striking the blades made the gun busses obsolete. However, planes other than military types have been built with the thrust behind the main wing. Jane's Encyclopedia of Aviation shows 30 such aircraft! McMahon's gun bus biplane is actually a scale model of the A.B.C. aircraft as noted in the McMahon description. So it is possible to build scale models which have the engine protection feature.

Suzor's plane has parallel outriggers for the tail, while Hansen & McMahon outriggers angle from the wing(s) to join at the tail.

The Suzor air tanks with the double deck arrangement is seldom seen but worth noting. Pavely is the only other COMPRESSED AIR modeler that I know of to use this unique arrangement of tanks to carry more air aloft.

I would respectfully suggest that a plane similar to one of the three ships having the engine & propeller between the wing & the tail assembly be built. You will not be sorry! With the newer tough plastic tank noses out front, they should be able to absorb quite a bit of energy in a crash with little damage to the tank & the rest of the model. So study these plans & build your version of this engine saving type.

N.A.S.A. is using a 22 Foot span "Mini Sniffer" model of this-motor behind the wing & in front of the tail assembly-type for a variety of unmanned missions.

HANSEN COMPRESSED AIR POWERED MODEL AIRPLANE-CANARD

Raymond C. Hansen was secretary of Pacific Model Aero Club of San Francisco, California. This was a very progressive & active club whose members gave a very good account of themselves in any contests entered. Mr. Hansen designed & built several fine COMPRESSED AIR models.

One of Hansen's models is a design easy to construct & fly. It is a conventional single pusher monoplane powered by a COMPRESSED AIR POWERPLANT.

Starting with wing, total spread was 54" & chord was 8",two wing halves being attached to sides of crutch which is main frame. One piece elevator straddles crutch. Elevator trailing edge is cut away, so that plane will have angle of incidence. Landing gear front & rear is made up of umbrella ribs, heated locally to flatten where joined. Hansen tied with thread & glue. (Author favors fine wire & solder for joining!) Two 2" wheels were used in front & a single wheel at the rear.

Main wing is braced with fine wire to the pylon on upper side & tail wheel support on bottom. Provide dihedral equal to at least 3" at wing tips.

Compressed air motor with approximately 9/16" diameter bore & 1" stroke was used, but any motor of similar displacement & reasonable efficiency should fly this simple model satisfactorily. Hansen used a twin opposed motor.

Tank measures 18" long by 3" diameter. It was brass .005" thick & wire wrapped. Tank was attached to crutch with threaded through-rods, soldered at each end. Nuts secure tank rods to crutch.

Stout linen thread was used for trailing edges of wing & elevator.

Propeller diameter of 14" plus or minus an inch or so according to power of engine & pitch of about 1.4 times diameter may be tried to get best performance

Author would use a little dihedral in the elevator rather than flat configuration Hansen used.

Center of gravity should be about 3" in front of main plane entering edge.

Adjust for best flat glide by moving elevator forward or backward as required.

Thrust at full pressure should equal at least 50% of weight of model. Therefore build <u>your</u> model as light as is practical. Hansen used 150 psi maximum pressure.

HANSEN COMPRESSED AIR POWERED "GUN BUS" MONOPLANE

One of Hansen's later COMPRESSED AIR model designs was this fine flier. Though most "Gun Bus" type ships were biplanes, plan view resembles a gun bus.

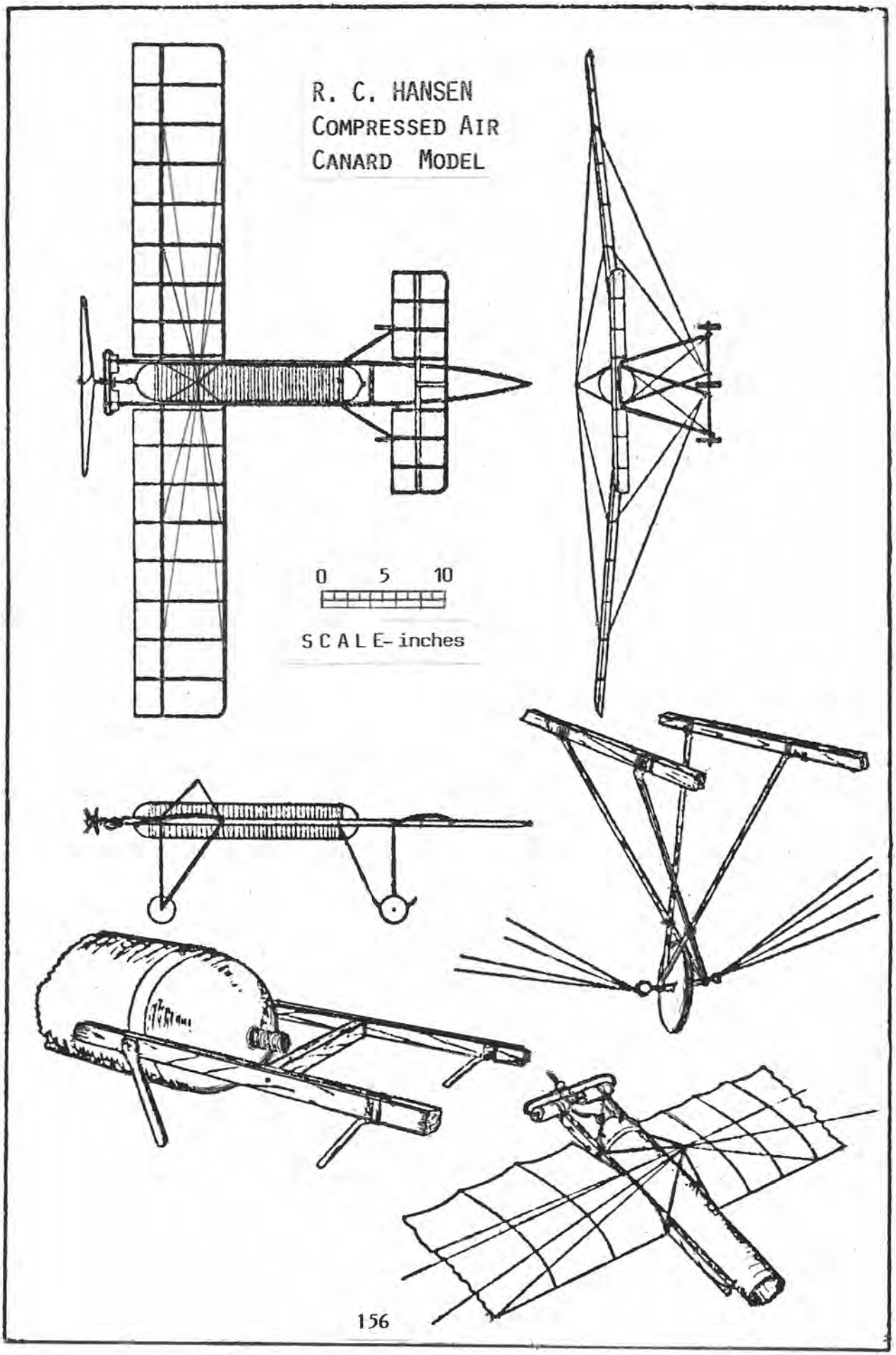
A three cylinder rotary engine was used on original model. However most any engine of similar displacement, which with propeller provides sufficient thrust, will fly bus equally well.

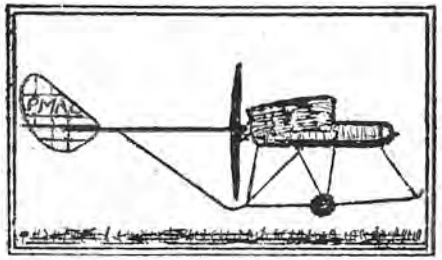
Hansen's construction materials were: .004" brass for tank cylinder 2-1/2" diameter by 14" long; spruce for elevator & wing beams; cork for 2-1/2" diameter wheels; spruce for two top outrigger struts; bamboo for bottom outrigger strut; bamboo ribs, wing tips & elevator & rudder outlines; goldbeaters' skin for covering rudder & elevator; fine silk doped lightly for wing covering, single surfaced; basswood for propeller; linen thread for those antique scalloped trailing edges; brass tube to connect engine & throttle valve on tank; piano wire "reinforcing" on tank; small steel compression coil springs on each rear landing gear wire struts to act as shock absorbers; umbrella rib for cross piece between wheels; piano wire struts to connect umbrella rib axle cross piece with tank through rods; tank through rods of steel threaded for attaching landing gear struts & steel wire king post for wing bracing wires.

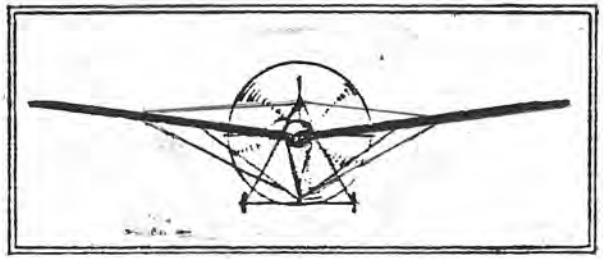
Hansen used a 3 cylinder rotary engine of 3/8" bore & 5/16" stroke. Pistons had cup washers of leather to seal against air leakage past pistons. A WHIRLWIND or other equal engine would perform as well or better.

Wing curve used was Eiffel #32 with its reversed or 'reflexed' curvature at trailing edge.

This excellent model, if built lightly using bamboo in place of steel for struts & using a 122 cubic inch plastic tank & balsa propeller, should far exceed 40 second flights & 400 feet distance obtained by Hansen! So add a dethermalizer!


R. C. HANSEN
COMPRESSED AIR
CANARD MODEL
0 5 10
SCALE- inches







SCALE----*inches*

HANSEN

COMPRESSED AIR MODEL

The Dragon Fly Mark-II

This model plan appeared -as a gas model-in the January 1947 issue of "Model Craftsman" magazine. The English SAM 35 Yearbook #3 published this plan but without the descriptive material. The most striking feature of this model plane layout, as stressed in the "Model Craftsman" article, was the durability of this ship. Propellers never were broken. The engine was never damaged. The model in fact survived so many severe landings that the push prop arrangement should have become very popular.

Danny Sheelds & Tom McCoy made many record COMPRESSED AIR model flights with a Kingburd gas model lightened for COMPRESSED AIR flying. So here is an ideal plan for making a COMPRESSED AIR model. The motor & propeller are behind the wing, out of harm's way. The original weight of the gas model is listed as 45 to 50 ounces. For your COMPRESSED AIR model you can reduce this to as little as 8 to 12 ounces easily. In place of the "rock hard" balsa called out on the plan, use medium weight balsa such as you would use on any good Wakefield ship. The wood cross section sizes can be reduced considerably. For example, the trailing edge of the wing was called out as 1/4" x 1" . For the COMPRESSED AIR model a 1/8" x 1/2" wedge would be ample at 1/4 of the sectional area & more than a 75% reduction in weight of the piece. For the wing spars in the gas model, you could use one of those "Think Tank" super light, yet extra strong, beams which are described elsewhere in the book & eliminate the lumber yard of spars & balsa sheet. Twisting of the wing is prevented by the "super spar" so the sheeting is not needed for torsion. The tail booms also help to keep the wing true. Your wing should not weigh much over 2 ounces. I have a strong COMPRESSED AIR model wing 10" x 80" which weighs just 2-1/4 ounces & it does not have that "super spar" either!

I have not included the details of the Dragon Fly fuselage because the air tank(s) will be the only fuselage that you need! You tape the front wheel yoke to the tank(s) & screw the rear axle wire to the flange ring on the plastic air tanks. For super light yet strong wheels for our air model, use a foam core disc 3/16" thick reinforced at the center with a balsa disc on each side & a short piece of aluminum tube for axle bearing. It hardly pays to cut lightening holes in these wheels because the foam core is so light. I harden the tread area with white glue. Most other glues attack the foam. See the section on tanks & also the Bottle Baby #2 plan.

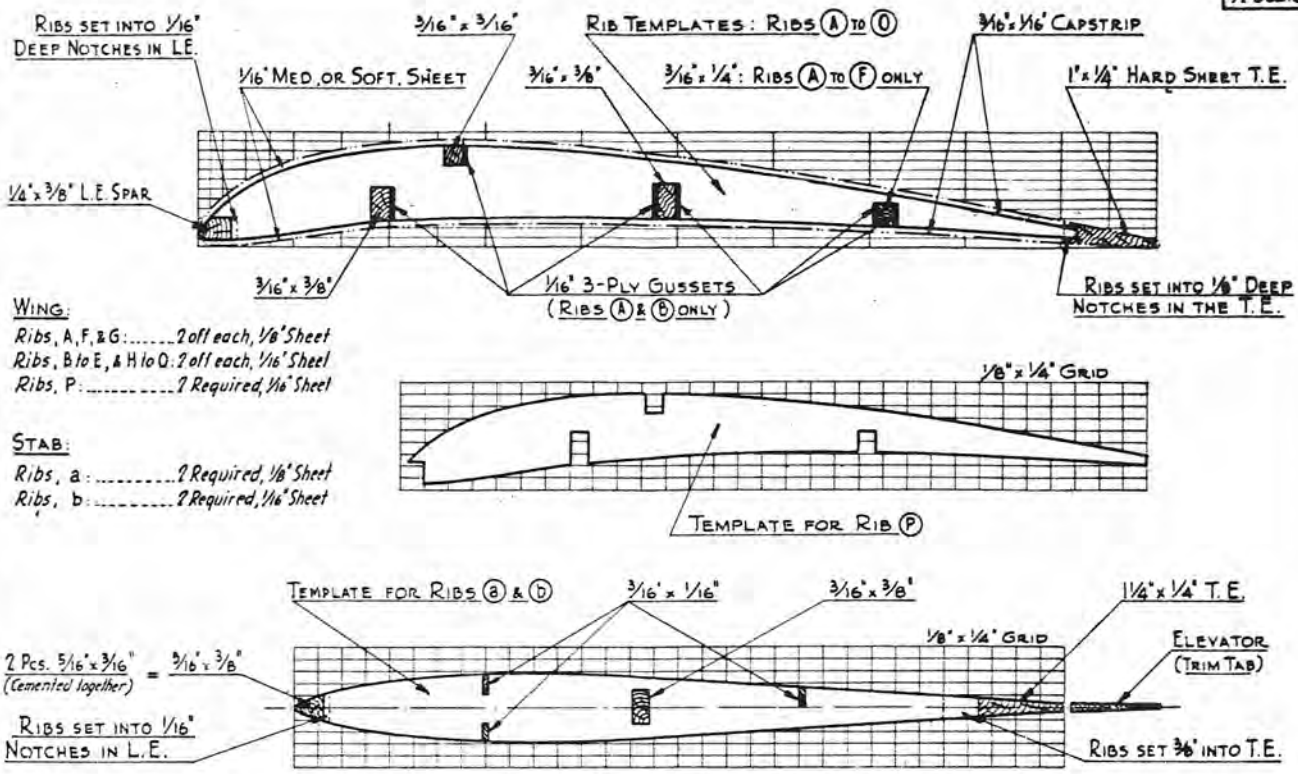
Although a single 122 cubic inch or a 183 cubic inch plastic air tank will fly this model, it has sufficient wing surface & is light enough so that twin in-line tanks may be used to increase the duration of flights. You can even go to two sets of twin in-line tanks side by side after you become experienced with COMPRESSED AIR modeling. The 4 tanks of 122 cubic inch size weigh no more than a single 3" x 24" brass tank, so weight is not any problem. Just think, you can pump 4 or 5 cubic feet of air into these 4 tanks & the engines usually use only about 1 cubic inch for every 4 revolutions. The propeller should be opposite hand from what it would be if used up in front. It should have a pitch to diameter ratio of about 1.4 to 1. Depending upon the engine, the size of the propeller selected should provide sufficient initial full air pressure thrust to equal approximately 1/3 of the weight of the whole machine. This should enable the model to take off of the ground-R.O.G.- & make a fast climb. See section on measuring thrust.

The tank(s) should be suspended from a light weight cabane strut arrangement below the center of the wing. A pair of parallel bamboo splints can be used to tape the tank(s) to. In this way the center of gravity can be adjusted merely by shifting the tank(s) as required. The full width elevator flap is not required unless you are thinking of making the model radio controlled. Usually only rudder control is all that is required on radio controlled COMPRESSED AIR models, since the elevation is normally preset.

I would strongly advise that a dethermalizer be used, such as a pop-up elevator. A number of the old heavy brass tank COMPRESSED AIR models have been lost in out of sight flights so these lighter plastic air tank ships certainly deserve this D.T. protection from becoming lost.

You may wish to study the effects of high & low elevator positions as shown on the plan.

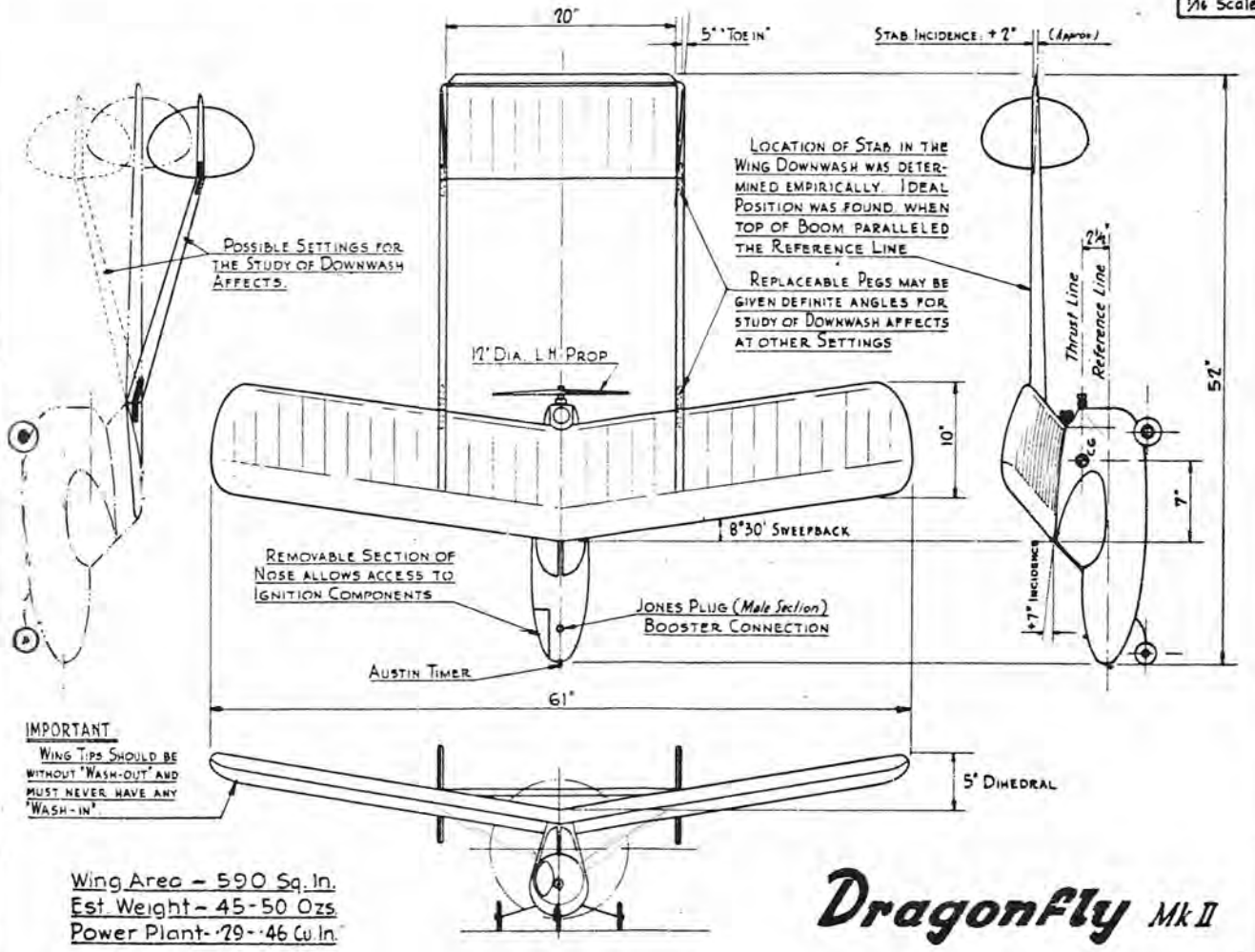
PLATE 2
½ Scale



Wing:
Ribs, A, F, & G: ..... 2 off each, 1/8" Sheet
Ribs, B to E, & H to Q: 2 off each, 1/16" Sheet
Rib, P: ..... 1 Required, 1/16" Sheet

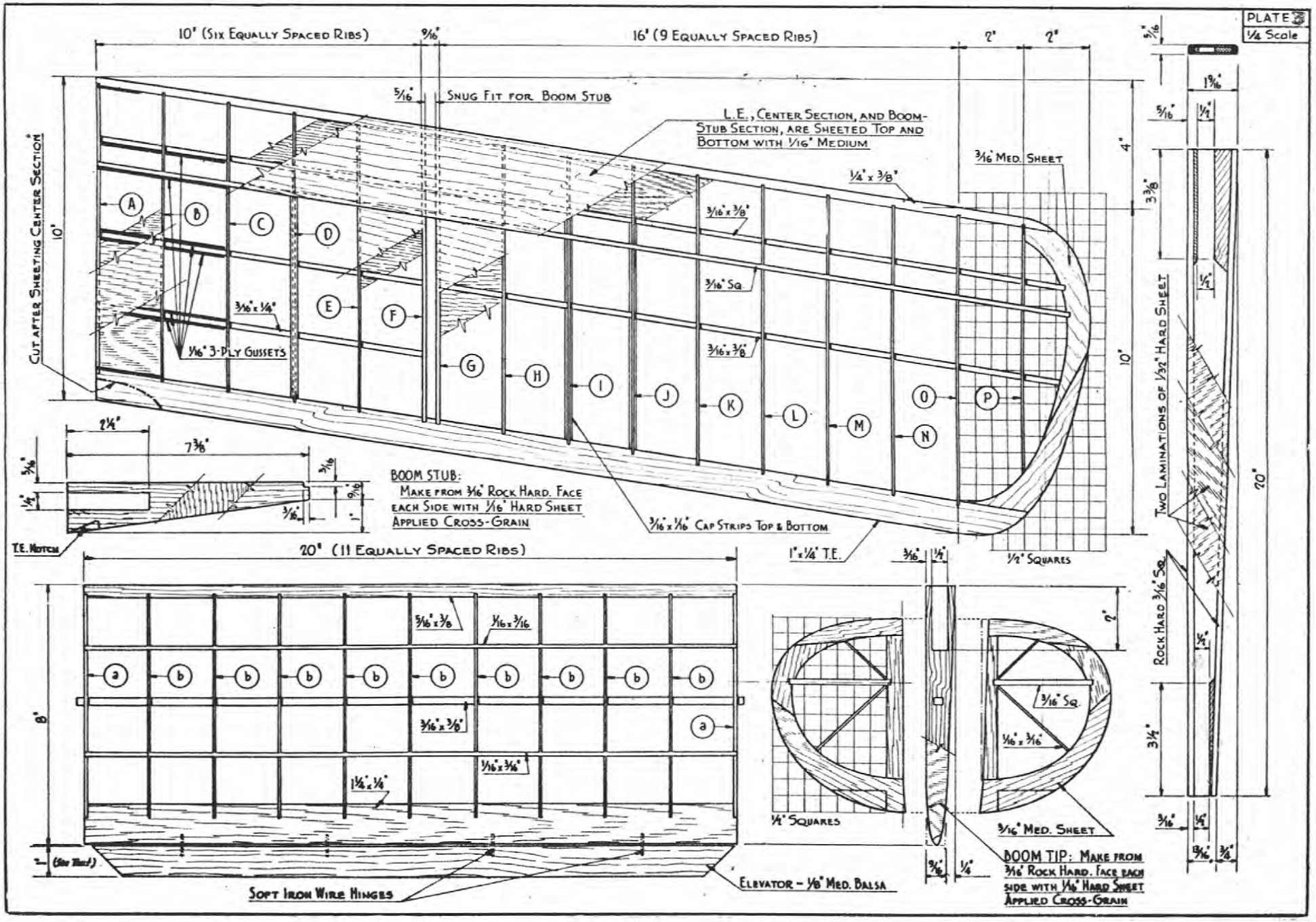
Stab:
Ribs, a: ..... 1 Required, 1/8" Sheet
Ribs, b: ..... 1 Required, 1/16" Sheet

PLATE 3
1/16 Scale



Wing Area – 590 Sq. In.
Est. Weight – 45-50 Ozs.
Power Plant – .29 – .46 Cu. In.

Dragonfly Mk II


PLATE XIV
1/4 Scale
10' (Six Equally Spaced Ribs)
9/16"
16' (9 Equally Spaced Ribs)
2'
2'
5/16"
Snug Fit for Boom Stub
L.E., Center Section, and Boom-Stub Section, are Sheeted Top and Bottom with 1/16" Medium
3/16" Med. Sheet
1/4" x 3/8"
3/16" x 3/8"
3/16" Sq.
3/16" x 1/4"
1/16" 3-Ply Gussets
Cut after Sheeting Center Section
10'
4"
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
2 1/4"
7 3/8"
3/16"
1/4"
9/16"
1"
3/16"
Boom Stub:
Make from 3/16" Rock Hard. Face each side with 1/16" Hard Sheet Applied Cross-Grain
3/16" x 1/16" Cap Strips Top & Bottom
T.E. Notch
1" x 1/4" T.E.
1/2" Squares
20' (11 Equally Spaced Ribs)
5/16" x 3/8"
1/16" x 3/16"
a
b
3/16" x 3/8"
1/16" x 3/16"
1 1/4" x 1/8"
8'
1/4" Squares
3/16" Med. Sheet
3/16" Sq.
1/16" x 3/16"
2"
9/16"
1/8"
Soft Iron Wire Hinges
Elevator - 1/8" Med. Balsa
Boom Tip: Make from 3/16" Rock Hard. Face each side with 1/16" Hard Sheet Applied Cross-Grain
5/16"
1 9/16"
1/2"
3 3/8"
Two Laminations of 1/32" Hard Sheet
Rock Hard 3/16" Sq.
3 1/4"
20"
3/16"
13/16"
3/16"

McMAHON COMPRESSED AIR POWERED BIPLANE

John F. McMahon was editor of model sections of "Aerial Age." McMahon was last of a series of model section editors until "Aerial Age" ceased publication in July 1923. McMahon along with Frank Schober, Rudolph Funk, Willard Dart & other members of Aero Science Club designed, built & flew COMPRESSED AIR models regularly. McMahon had experimented with a C.A. monoplane which he was able to fly either as a tractor or as a pusher. Since damage was more frequent & severe with tractor models, McMahon became a proponent of pusher compressed air models.

He designed & built this stand-off scale model of Vincent Burinelli & John Carisi A.B.C. pusher prototype military plane. Big ship carried two machine guns with a wide angle forward range of fire. Air tank on model resembles nacelle of full sized machine. A twin opposed C.A. engine of 9/16" bore & 1" stroke attached at rear of a 3" diameter x 10" long tank flew this machine with a 14" diameter pine propeller which had an 18" pitch. Balsa wood was unavailable. Depending upon engine direction of rotation, a left hand propeller is often required on pushers. Upper wing span was 42" & lower wing spanned only 24". Chord was 6-1/2" at center & 5-1/2" at tips on both wings. Total wing area was 396 square inches. Wings were single surfaced & covered with fiber paper. Wings were built up with two 3/16"dowels planed & sanded to a streamline shape. Cambered ribs & wing tips were bamboo. All of scalloped trailing edges were small diameter wire. Wing tips had wash-out for anti-stall & stability in flight. Dihedral should be 2" to 3" on upper wing tips & half that for lower wing. Note sweep back of wings. One set of bamboo struts separated wings by 6" on each side of center. These streamlined struts were located at junction of outriggers. Tank was nestled between two sets of struts.

Outriggers which support tail surfaces were 3/16" diameter planed & sanded to a streamlined shape.

Tail surfaces are double covered & built up of bamboo & reed or rattan.

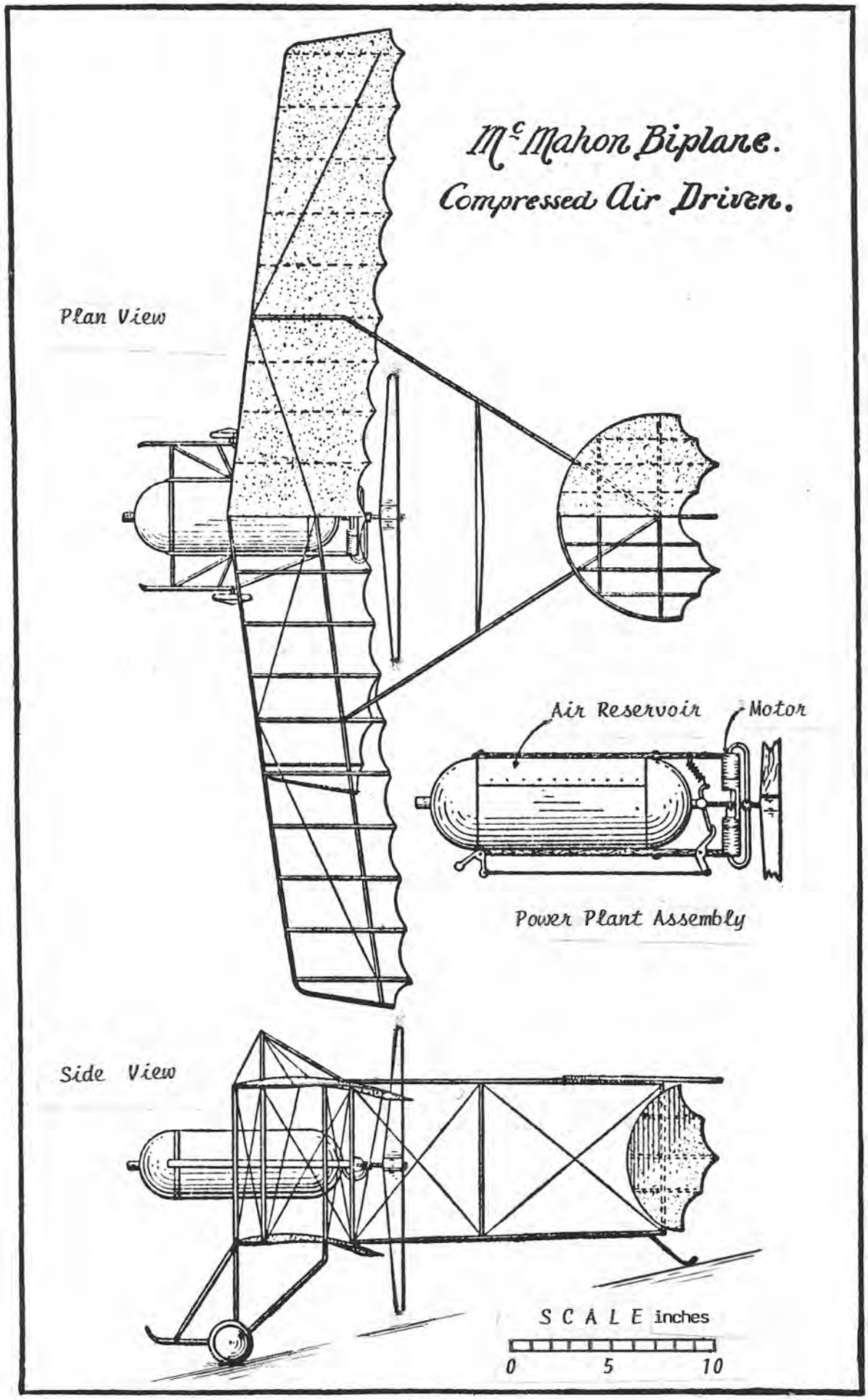
Landing chassis was made sturdy -" in order to withstand the most violent shock that the chassis might possible receive upon landing." McMahon had learned that a strong chassis saves damage & consequent repairing which subtracts from fun of flying whether model be tractor or pusher.

Thrust adjustments to attain desired stability under power could be made easily on this type of model by tilting tank slightly as long as propeller does not strike wings. McMahon discovered that throttle was in a very inaccessible location, so he elected to use a spring loaded cock valve shaft in combination with trigger-like device so that throttle could be actuated from in front of model. A cock valve flexible shaft extension would be more simple & probably lighter in weight, as well as being more positive than a spring operated valve.

A twin cylinder engine may not always be in an angular position to start when valve is opened so propeller may need to be flipped in normal direction of rotation to start. Flights of 15 seconds & 200 feet were common.

McMahon's classy looking model built lighter & with a larger air volume plastic tank could be expected to fly much longer & farther. Volume of 3" diameter x 10" tank is 63-5/8 cubic inches. Tank weighed 7 ounces. A plastic tank of 122 cubic inches volume, weighs only 1-7/8 ounces! So with about 1/4 weight of metal tank & almost twice the volume spectacular results could be expected. Weight may be saved by use of balsa propeller, tissue covered balsa rudder & elevator. Fishing line of mono-filament type for bracing & trailing edges & balsa wheels would save additional weight. Of course we would expect to have to add weight of a good dethermalizer with all of those duration additives!

Just build light & strong. Adjust for flat glide without power. Adjust thrust for best climb without stall & you will be center of attraction at any contest!


Mc Mahon Biplane.
Compressed Air Driven.
Plan View
Air Reservoir
Motor
Power Plant Assembly
Side View
SCALE inches
0
5
10

Donald Burnham's COMPRESSED AIR Pusher Model.

A picture of this model appeared in the January 1931 issue of the "American Boy" magazine. Burnham had become a builder & flier of prize winning rubber driven models. In 1929 he won the prestigious Mulvihill Trophy. Among prizes which he had won was a Hoosier Whirlwind COMPRESSED AIR motor mounted on a 2-1/2" diameter by 24" long seamless brass air tank. He did not waste any time in designing & building this model plane to be flown with his new power plant. Because the ship was to be a free flight model, he decided to put the motor & propeller in a safe place- behind the wing where these most important parts would be well protected. This proved to be a wise decision because the model was flown many times without any damage to the power plant or the propeller. Burnham still has the tank & motor in excellent condition, stored in the box which it came in!

Since the Whirlwind is not reversible, note that for a pusher he had to carve an opposite hand propeller.

An interesting feature of Burnham's model is that he devised adjustable ailerons which he used to counteract the torque of the propeller.

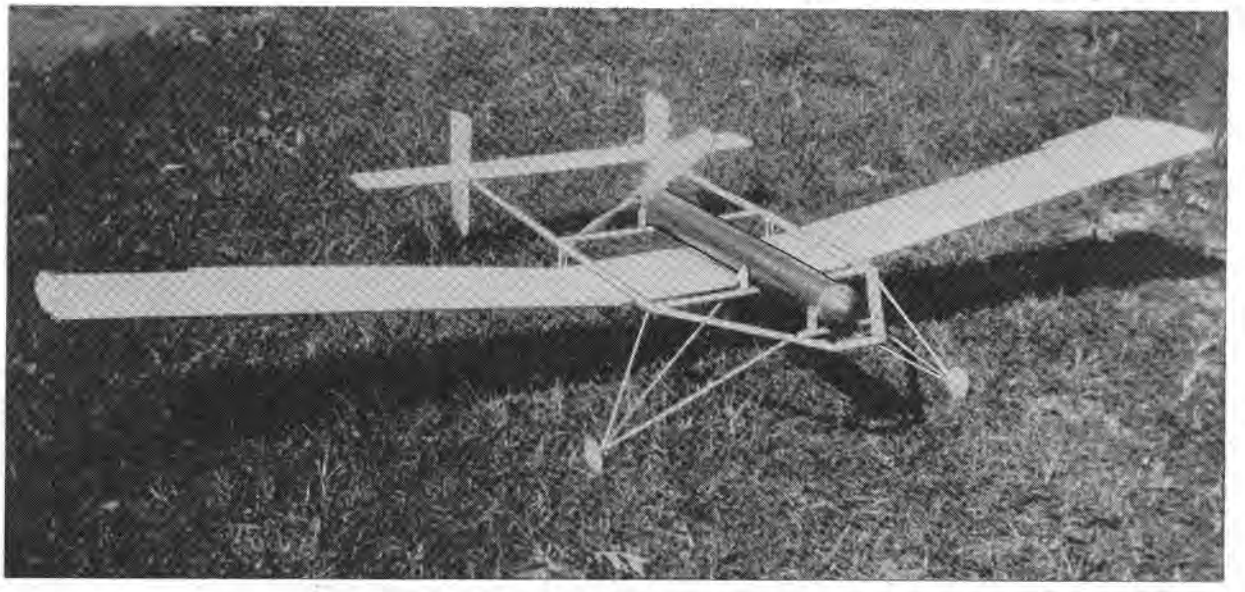
Note the three streamlined cross members in the fuselage. These were used effectively to support the tank as well as for attaching braces for the landing gear. The sturdy landing gear was made of bamboo, streamlined. Three struts supported each wheel so it had "independent 4 wheel suspension".

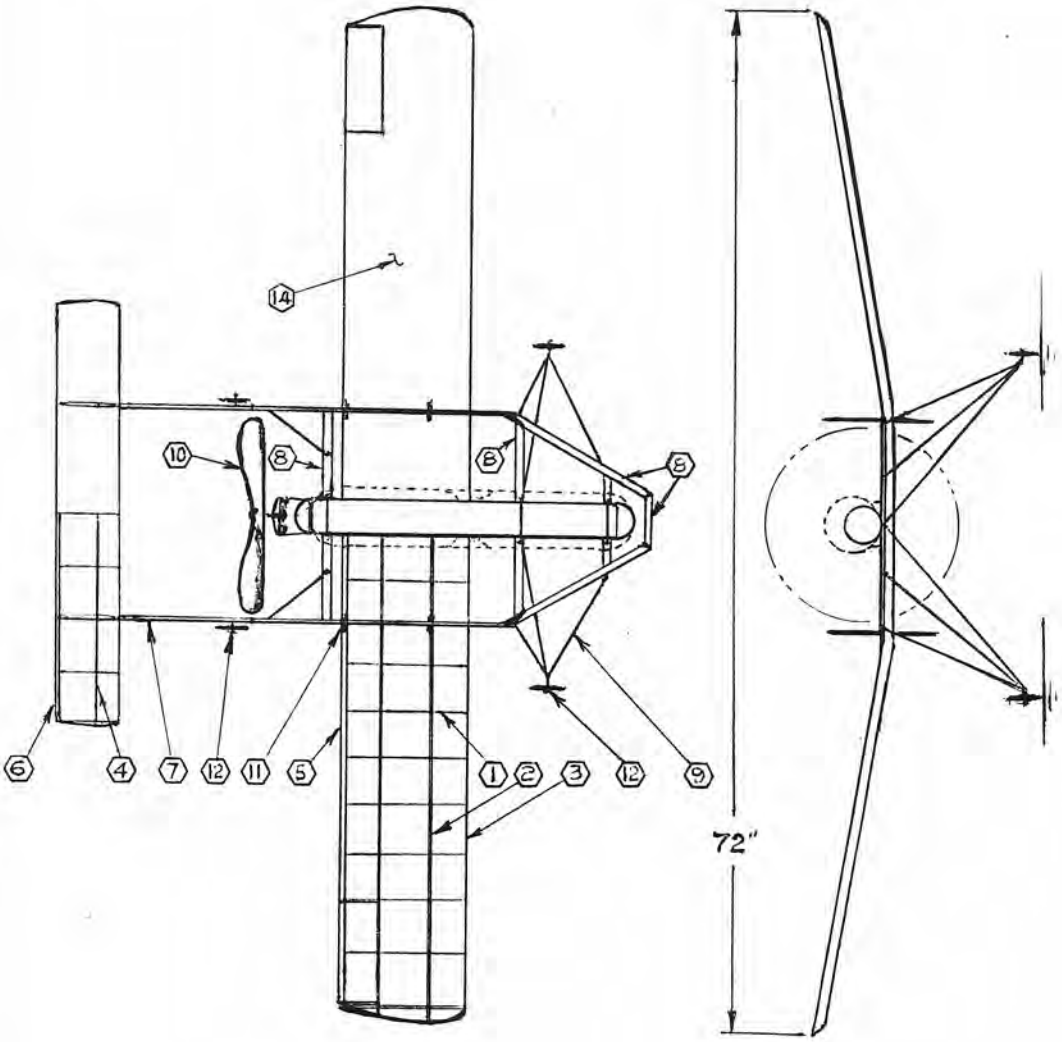
The wing had an aspect ratio of 8 making it an efficient glider when the power was all gone. The wing was fastened to the underside of the fuselage with 4 wire clips, two tall ones at the trailing edge & two short at the front wing beam. This type of mount did two things. It prevented the wing from twisting & it provided fore & aft adjustment. This allowed the model to be adjusted easily for balance.

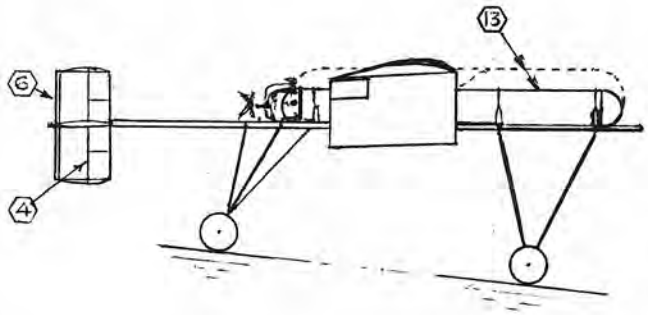
With the newer plastic air tanks available, you could build your own version of Mr. Burnham's interesting craft. I have dotted in the outline of a pair of tanks in a tandem arrangement to show how these tanks would appear. They would provide 110% more air capacity with 244 cubic inches available. Also they would weigh the same or slightly less than the brass tank.

Mr. Burnham wrote that if he were to build the model today he would endeaver to make the model climb higher such as using a smaller diameter propeller. This, combined with more air volume, would certainly accomplish his purpose.

You should consider equipping your Burnham COMPRESSED AIR model with an effective dethermalizer!







0 4 8 12 16 20
SCALE IN INCHES

DONALD BURNHAM COMPRESSED
Air Model Airplane---------- 1930

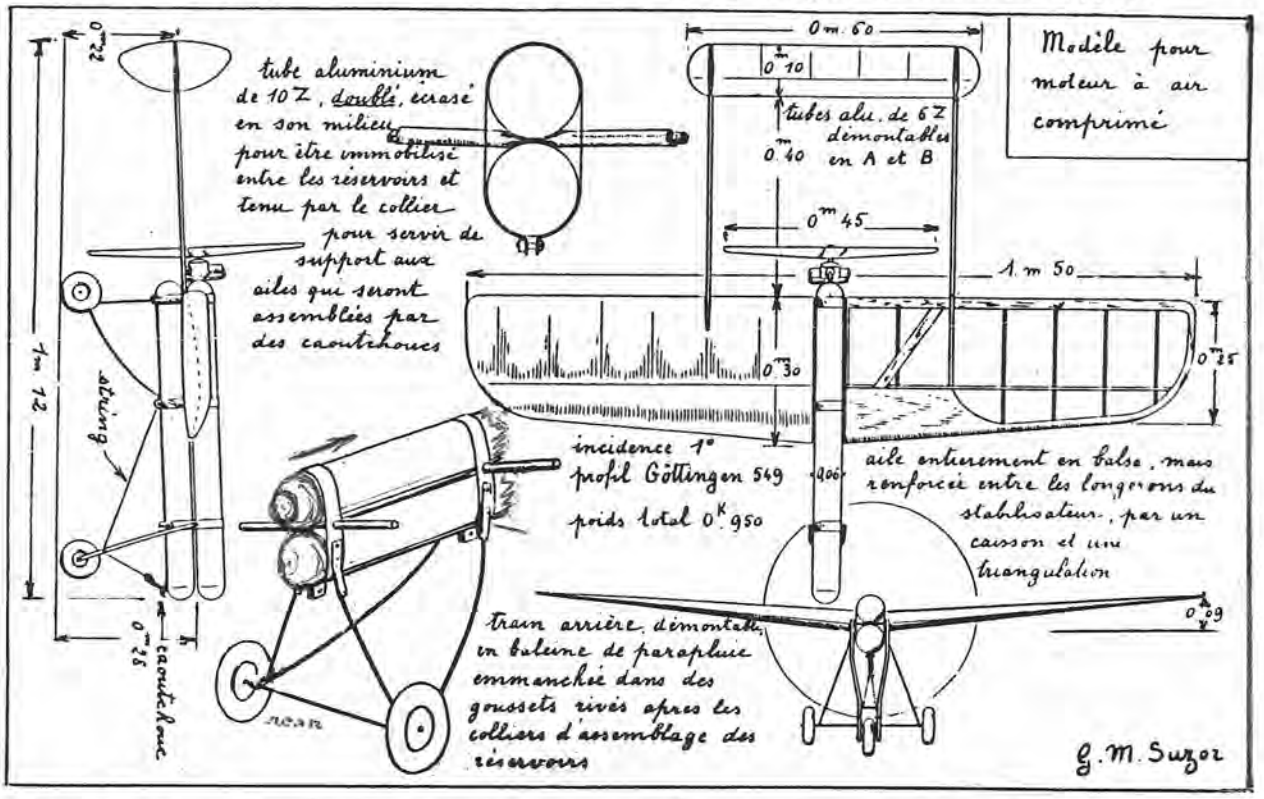
BILL OF MATERIALS-

1. 4-1/20" x 2" x 36" balsa
2. 4-3/16" x 1/2" x 36" balsa
3. 2-1/4" sq. x 36" balsa hard
4. 1-1/8" x 1/4"x 36" balsa
5. 2-3/8" V section x 36" balsa
6. 1-1/4" V section x 36" balsa
7. 2-3/8" x 3/4" x 36" balsa
8. 2-3/16" x 3/4" x 36" balsa
9. 12-1/16" x 3/16" bamboo- lengths to suit
10. 1-1⅛"x1¾" x 14" balsa
11. 1-ft. 1/32" steel wire
12. 2-ft. 1/16" steel wire
13. 1 power plant 3/8" bore & stroke 3 cylinder radial or equal & 24" long tank.
14. 2-1/2 yards silk or equal tissue

Bert Pond.

French COMPRESSED AIR Model by G. M. Suzor

Below is a very interesting plan of a French COMPRESSED AIR model. This model has a number of novel features. The motor & propeller are at the rear of the wing-between two outrigger tubes. The model is known as a pusher as far as the power unit is concerned. Note that the propeller must be opposite hand to that required for a tractor model unless the motor is reversible. Engine & propeller are protected. Another noteworthy feature is the use of two separate air tanks mounted parallel, one above the other. The small diameter tanks permit higher pressures. The two tanks hold more air for greater duration. Each tank is 2-3/8" diameter & 25-9/16" long. The motor is mounted on the rear end of the upper tank. The front portion of both air tanks is not shown at the rear of the perspective 3/4 rear view sketch. This view shows how Mr. Suzor attached the landing gear to the umbrella ribs, which in turn were fastened to the clamps for the tank. The landing gear assembly was removable. For wing half mounting, Suzor chose to flatten aluminum tubes on opposite sides of the center to fit the radius of curvature of the tanks. Then the tubes were passed through holes in the tank clamps to resist bending of the tubes. Then the wing halves were plugged into the tubes & retained with rubber bands.
Another interesting feature of Suzor's model is the hinged front wheel support.



A length of cord restrains this wheel support from swinging too far forward. Then a rubber band in front cord allows this front wheel strut assembly to move to the rear for absorbing landing shocks. Size of the rear landing gear wire would depend upon the weight of the model. However the front wheel struts may be made of bamboo about 3/64" x 7/32" streamlined.
Tank material, air pressure used & duration of flights are not known.
Data & dimensions converted to the nearest 1/16" follow:-
Wing-section Göettingen # 569

- -59" span
- -11 13/16" chord at center
- -9 13/16" chord near tip
- -1° angle of incidence
- -all balsa construction
- -3 1/2" "dihedral"
- -diagonal braced & planking over first 2 ribs in front

Tail -23 5/8" span elevator
- 3 15/16" chord elevator
-15 3/4" outriggers-length between trailing edge of wing & entering edge of elevator, to which add the plug in lengths. Outriggers are aluminum tubes 5/16"to 3/8" in diameter. Hollow fiberglass tapered fishing rods make a good replacement.

Overall length of model 44 1/8"

Landing gear
-3 1/2"diameter wheels (3)
-8 5/8" elevator trailing edge to ground
-11" at front between tanks to ground

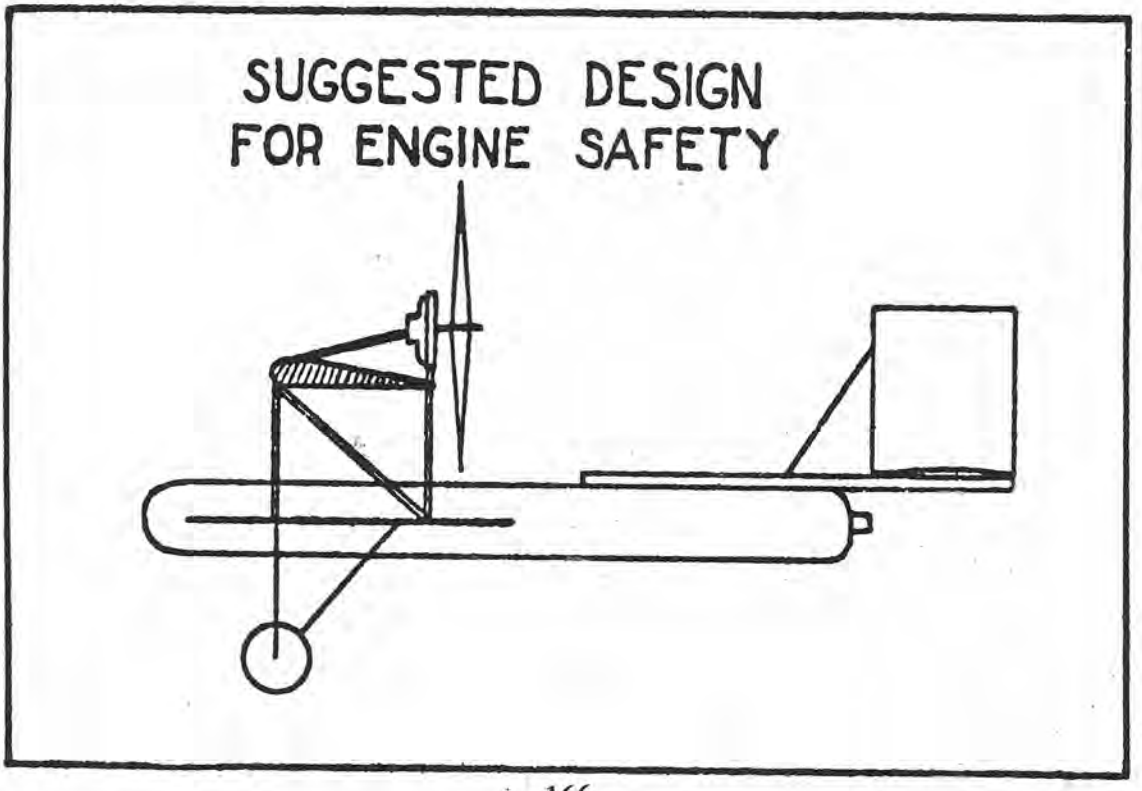
Propeller
-17 3/4" diameter
-20" pitch-estimated

Weight
-33.5 ounces total

The tanks may be shifted axially as required in order to secure proper flying trim by loosening small screw which hold the tank/wing clamps.
This general configuration using your own materials & construction techniques along with the light weight plastic air tank should provide you with a high performance ship. See section on tanks. Two 122 cubic inch plastic bottles in line would be only about 3 1/2 ounces & would provide a large volume of air-almost 3 times the volume of Suzor's tanks.
So make your landing gear strong . Never over pressure your tank!
Practice flying the model until you know how to get the best duration from the model under all conditions.
You are then ready to compete.

Another Way to Protect Your Engine & Propeller.

The layout shown below appeared in a magazine article a number of years age. It conveys the idea that the motor & propeller should be in a proected area. That advice was good then & it is still good now for all engines including expansion types.



A Radio Controlled COMPRESSED AIR Model-by Fritz Mueller.

A COMPRESSED AIR model is unusual, but a radio controlled COMPRESSED AIR model is indeed much more rare! Mr. Mueller designed & built this very unique flier. He made numerous flights of approximately 60 seconds each. His pump would only put 80 psi. in the tank, limiting the time of flights.

Specifications:

Wing-span 65"; chord 10-1/4"; wing section upper surface NACA #4415-lower surface camber added; weight including 4-183 cubic inch air tanks---18.16 oz.

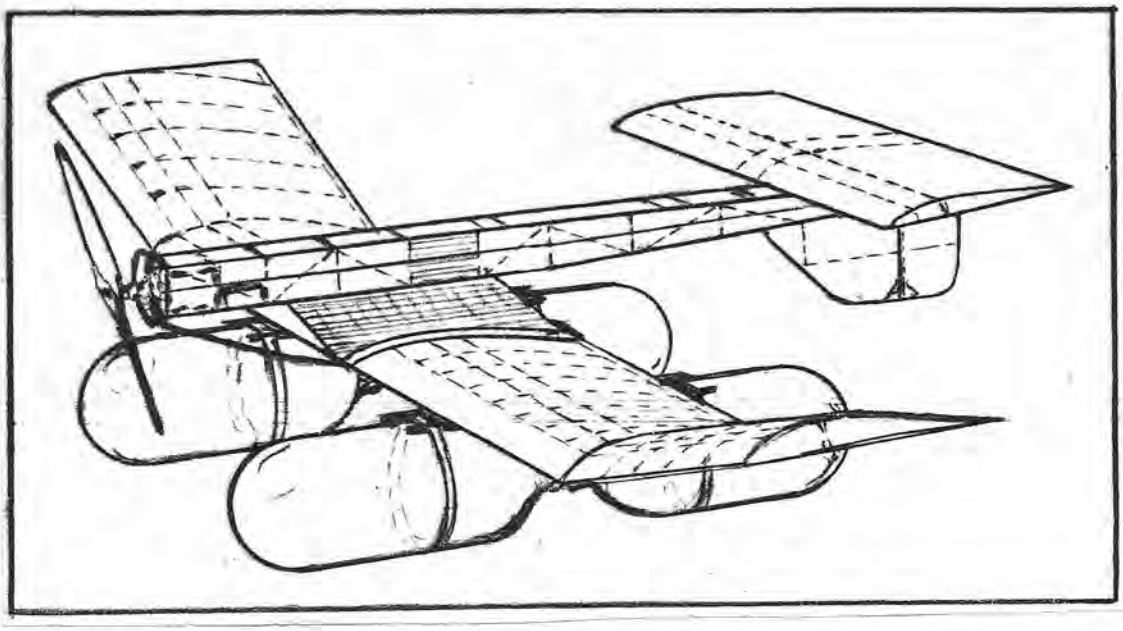
Elevator-span 23"; chord 8"

Fuselage-weight including elevator, rudder, radio, batteries & servos (2)----- 7.69 oz.

Power plant-Hoosier Whirlwind; propeller 12" dia. x 6" pitch hardwood (gas model type); weight engine & propeller---------- 1.94 oz.

Model-total weight-less pressure air----------27 .79 oz.

Air weight @ 80 psi. approximately---------- 3 .00 oz.



Fritz used the Cannon Super Micro radio, the lightest available with servos. The 80 psi. is approximately 5.44 times normal atmospheric pressure. Therefore, the volume of free air in the 4 tanks is 4 x 183 x 5.44 or about 4,000 cubic inches or 2-5/16 cu. ft. The same number of 122 cubic inch plastic tank would hold a higher pressure with less weight. The greater energy from the higher pressure combined with less weight & air resisitance would certainly increase the performance of this fine model even more. With a faster climb & a flatter glide the endurance could be doubled easily.

Mueller's model is conventional balsa construction. A pylon angles down from the fuselage with a contoured pad to fit the upper surface of the wing. An aluminum clip holds the front of the wing & a plastic screw holds the rear of the wing to the pylon. The pylon is braced top & bottom with 1/2" triangular balsa fillets.

The 14-1/2" long wing tips are raised 4-1/4" at the tips for stability.

The twin tanks are mounted with tape to 3/8" balsa triangular pieces cemented to the wing so that the tanks are 8" from the center of the wing.

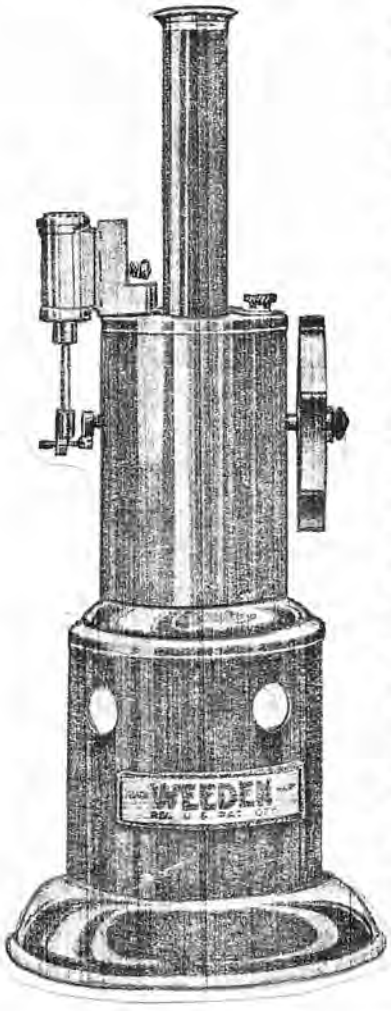
The lack of a landing gear makes hand launching mandatory. The plastic tanks are quite durable & if flown in grassy areas the model should not be harmed.

The feature of Mr. Mueller's model which impresses me most, other than the radio control, is the large air capacity which he was able to make airborn with such a small model.

This ship should set the pattern for many more COMPRESSED AIR record flights. Just be sure to test your tanks safely to a higher pressure than you will use in the actual flying.

Steam Power for Model Aircraft.

Your grandfathers, when they were young, probably enjoyed running the very popular Weeden toy steam engine as pictured on the left. This type of steam power had too much weight & insufficient power to fly model planes.



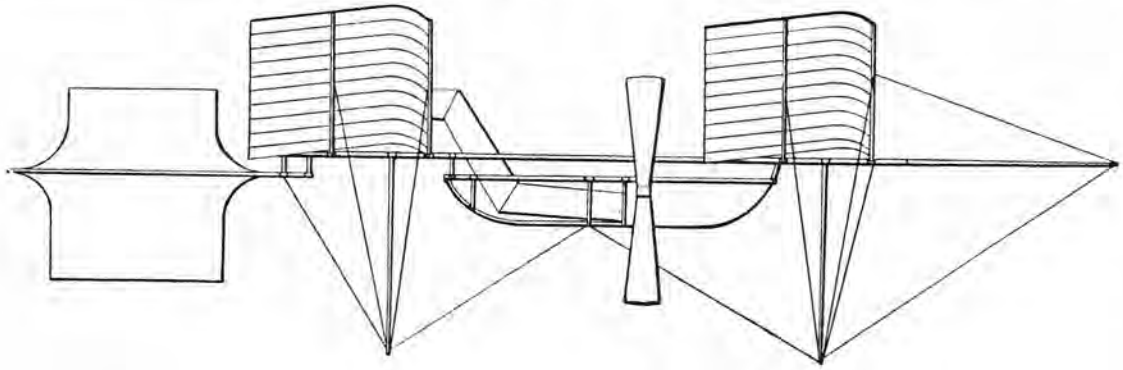
History records a number of early model plane flights which were powered by steam engines. Henson & Stringfellow were the more successful of the steam model fliers. No one had made flights longer than about 125 feet or more than just a few seconds.

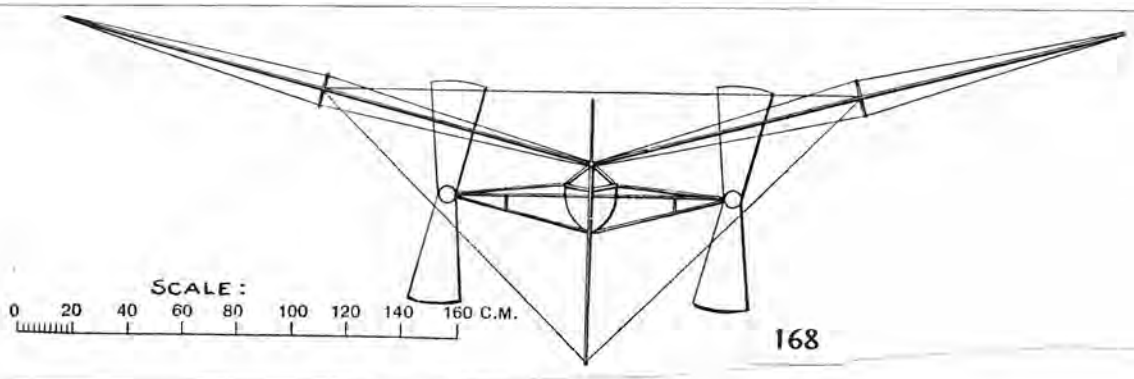
In 1891, Maxim's steam plant demonstrated that it had sufficient power to lift his large full size airplane.

Hargrave had bench tested two steam engines both of which had more power & endurance for about equal weight of powerplant than his successful COMPRESSED AIR model powered craft. It is unfortunate that Hargrave never put these superior engines to actual flight tests. He set them aside in order to attempt to improve his knowledge of the aerodynamics of wing surfaces.

Professor Langley, while in England, purchased Henson's steam powered model triplane & brought it to the United States. This model hangs in the Smithsonian Museum beside his own steam powered aircraft. This plane was a source of inspiration for Langley. Langley had researched & written a book,"Experiments in Aerodynamics" in 1891. In 1893 he had published a book,"The Internal Work of the Wind". Along with his "Langley Memoir on Mechanical Flight", these books are parts of Volume 27 of the Smithsonian "Contributions to Knowledge." All 3 are recommended reading. If your library does not have these books, they are usually able to borrow them from some other library for you.

Most all of Langley's efforts had the final objective of eventually developing a full sized man carrying aircraft. Illustrated below is the plan of his #5 Aerodrome which flew often & superbly well.





Langley's Steam Powered Expansion Engine Models.

Samuel Pierpont Langley's approach to creating a practical man carrying aircraft was by the gradual research & development route. He had at his disposal the shop facilities of the Smithsonian Museum & the able assistance of a Mr. Manley. For a short time Langley had the services of August Herring.

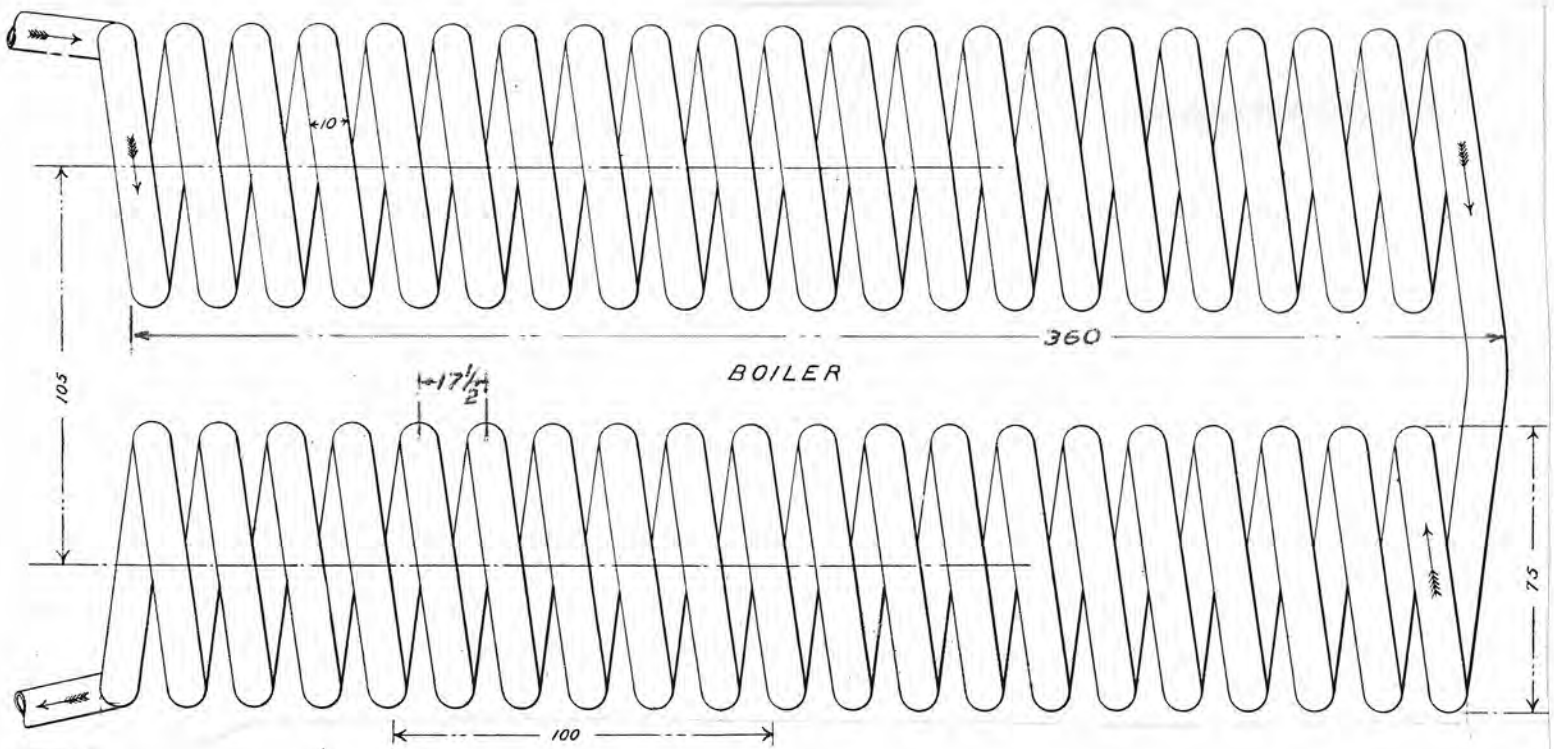
Langley's diary of his aeronautical work "Memoir on Mechanical Flight" printed by the Government Printing Office is in many large libraries. It is a large size book with many plans & illustrations.

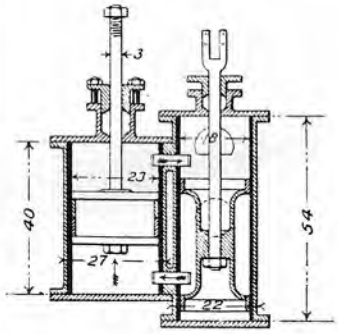
Langley started from "square one" by studying about every conceivable form of power & energy for possible use-from rubber strands to compressed gasses, steam, gasoline & even gun powder! He evolved his tandem plane arrangement which flew well & then stayed with this design.

The picture, courtesy of the Smithsonian Museum, shows this tandem wing flash steam powered plane just after being catapulted into the wind from atop a barge. Note the cambered single surface airfoil & the wing dihedral. The long flash boiler is shrouded to direct the heat efficiently up the rear stack away from the flammable materials of the structure. The steam models made many free flights of distances over water estimated to be one half mile & more.

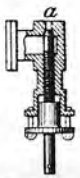
His one quarter size prototype of his planned man carrying ship flew exceptionally well with a 5 cylinder radial air cooled gasoline engine. As a result, Langley rushed his full size plane; & with confidence based on the fine performance of the numerous models, catapulted the big ship in front of a large crowd of press & officials into the river, pilot & all. This embarrassing accident resulted in the cutting off of funds. His aeronautical research work came to an abrupt stop. Interestingly, some time later, Glen Curtiss flew a Langley type float plane for a short distance in order to try to prove that Langley's plane had been capable of flight.



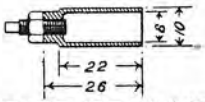




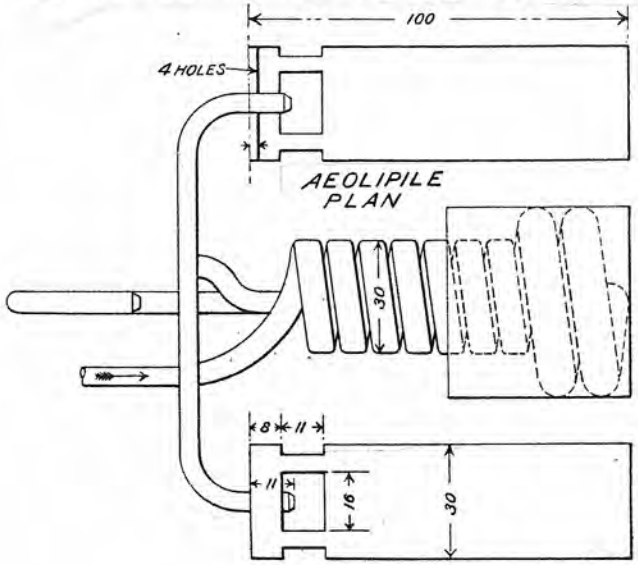
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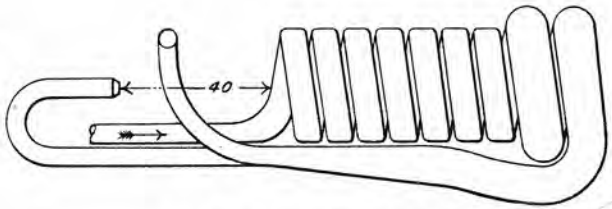


NEEDLE VALVE



THRUST BEARING





SIDE ELEVATION OF
EVAPORATING COIL
OF
AEOLIPILE

DETAILS
AERODROME № 5.
HALF SIZE
METRIC SCALE

170

A description of Langley's Aerodrome #5 is worth studying since it was the very first aircraft model which flew with any kind of power for a distance & time which proved that heavier than air machines were really to be the carriers of the future. 5 years of intensive work in testing wings on a whirling arm gave Langley the numbers which he needed to know that his "sustainers", as wings were called, could support the weight of his aerodrome in horizontal flight.

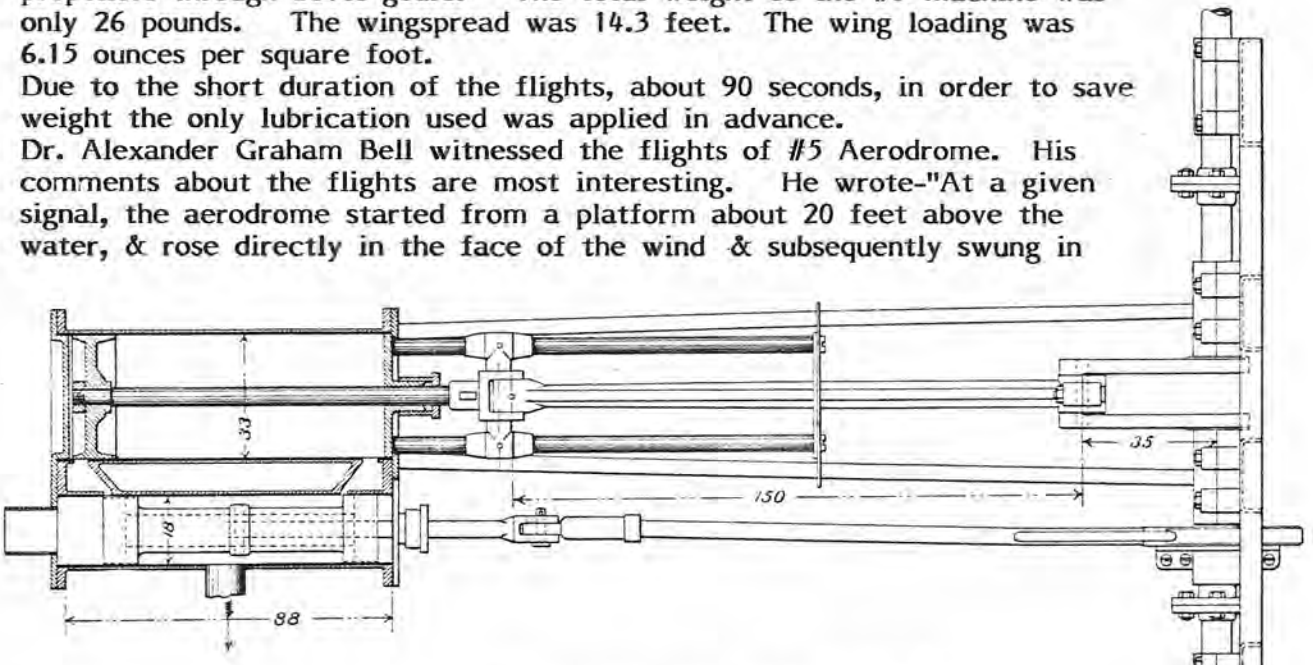
After testing many combinations of flash tube boilers & burners, there finally was evolved a unit which, on his pendulum thrust tester, provided thrust equal to 40% to 50% of the weight of the whole airplane. With this information, Langley knew that he was sure of making flights. He had switched from alcohol fuel to the more difficult to handle gasoline fuel. The drawing shows the final boiler & burner for #5 plus a few accessories, all in half size. Other items, not shown, are the separator which removed water from the steam. Another item was a floatation tank which kept the machine from sinking in the Potomac River. A shroud over the boiler coils confined the burner heat to the space where it would provide the most steam. The burner efficiency was improved by routing the exhaust steam through this shroud.

The engine, as shown in the drawing below, was a double acting single cylinder type with a cylindrical piston valve. The bore was almost 1-5/16" & the stroke 2-3/4". Depending upon the steam pressure, this little powerhouse produced 1 to 1-1/2 horse-power. The engine weight was a mere 26 ounces. No insulation or lagging was used, in order to save weight.

Note in the drawing that the shaft extends to both sides & drives the 2 propellers through bevel gears. The total weight of the #5 machine was only 26 pounds. The wingspread was 14.3 feet. The wing loading was 6.15 ounces per square foot.

Due to the short duration of the flights, about 90 seconds, in order to save weight the only lubrication used was applied in advance.

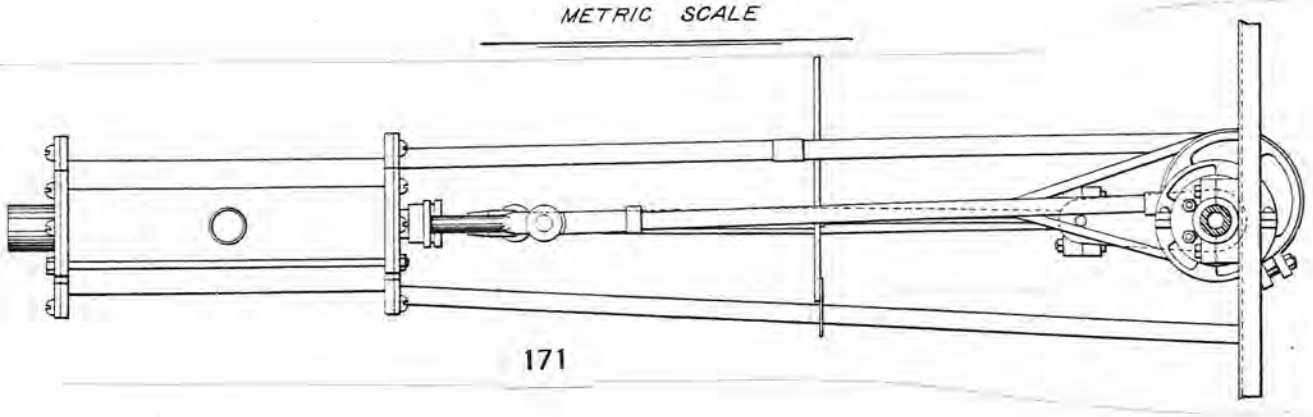
Dr. Alexander Graham Bell witnessed the flights of #5 Aerodrome. His comments about the flights are most interesting. He wrote-"At a given signal, the aerodrome started from a platform about 20 feet above the water, & rose directly in the face of the wind & subsequently swung in



1. HORSEPOWER ENGINE (N° 5)

HALF SIZE

METRIC SCALE



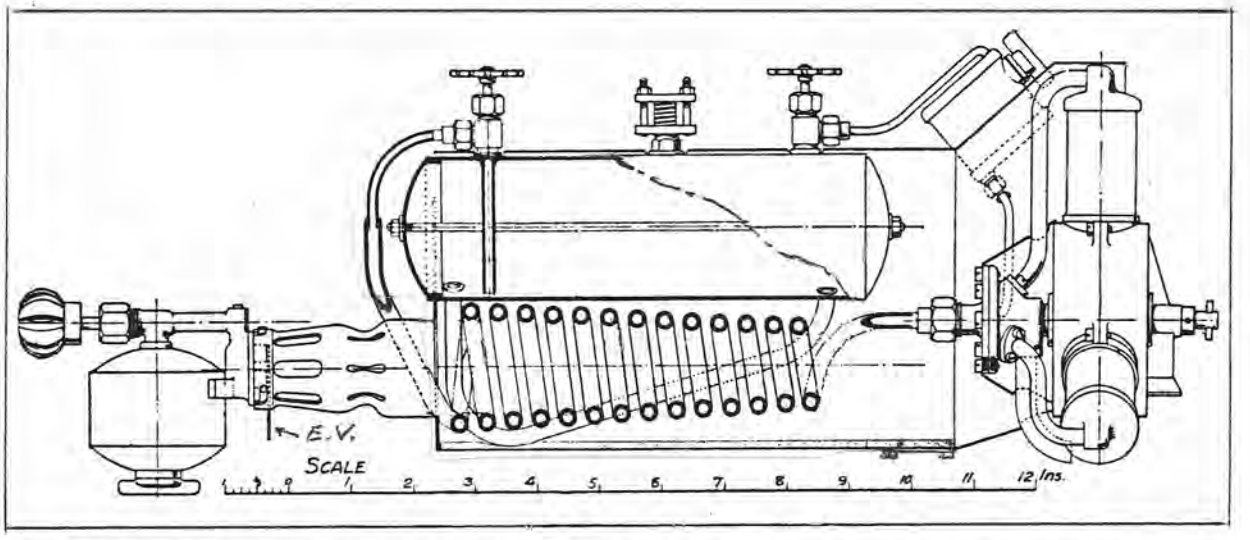
large curves of perhaps a hundred yards in diameter & continuously ascending till its steam was exhausted. When at a lapse of about a minute & a half & at a height which I judged to be between 80 & 100 feet in the air, the whole ceased turning & the machine deprived of the aid of its propellers, to my surprise did not fall but settled down so softly & gently that it touched the water without the least shock, & was in fact immediately ready for another trial.

"In the second trial, it repeated in nearly every respect the actions of the first. Its motion was, in fact so steady that I think a glass of water on its surface would have remained unspilled. When the steam gave out again it settled gently down. It reached the water in one minute & 31 seconds from the time it started, at a measured distance of over 900 feet from the point at which it rose.

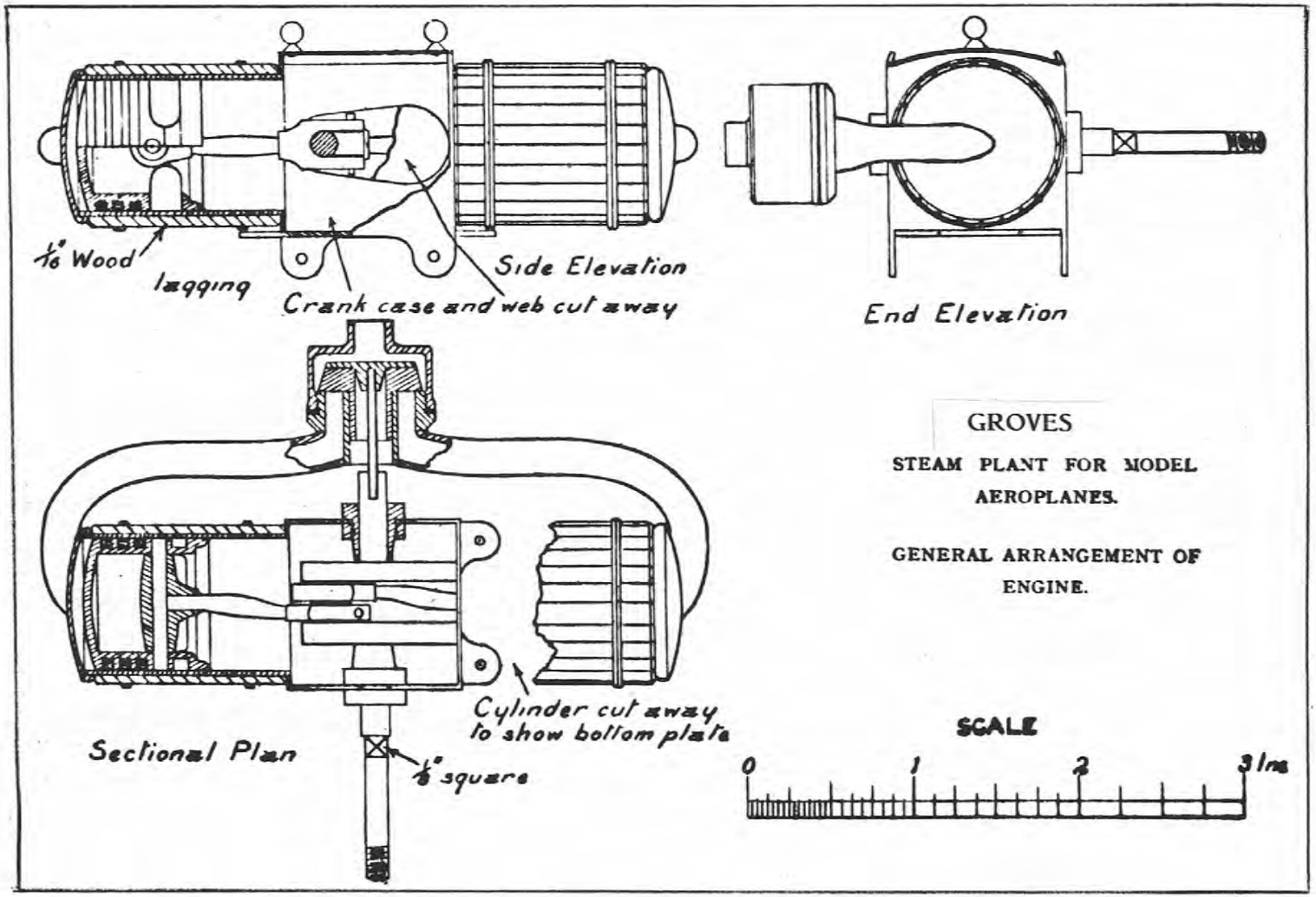
"This however is by no means the length of its flight. I estimated from the diameter of the curve described & from other measures that the length of flight on each occasion was slightly over 3,000 feet. It is safe to say that each exceeded half an English mile.

"It seems to me that no one who was present on this interesting occasion, could have failed to recognize that the practicability of mechanical flight had been demonstrated."

It is interesting to note that this #5 Aerodrome was flown as a tandem biplane at a later date. The original tandem monoplane flew slightly better so the biplane configuration was not tested further.

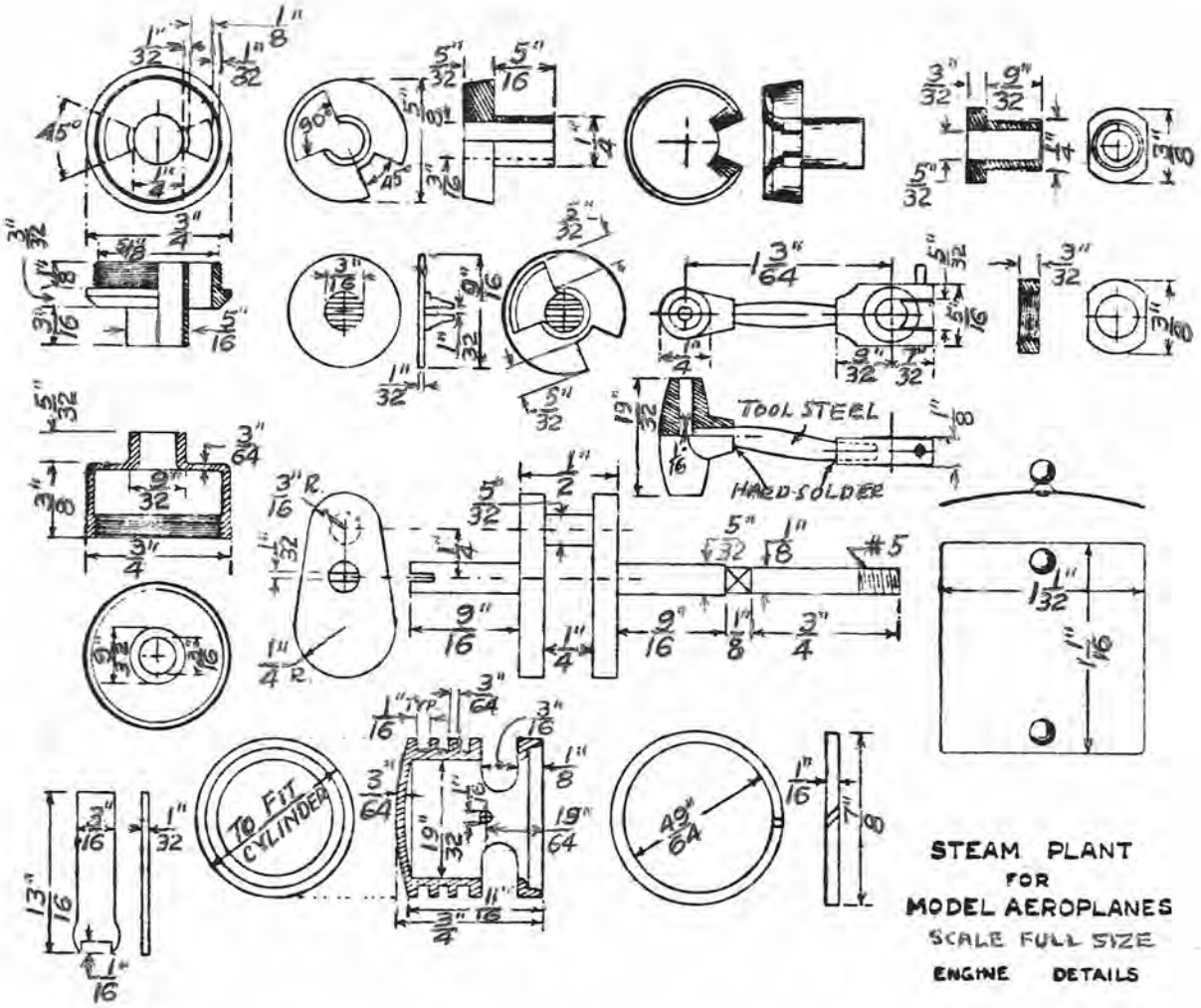


This is a boat type of steam plant which is evident from the forked drive on the engine shaft. It has many interesting features. Burner heat is shrouded & directed over the engine to minimize condensation. An oil tank provides a metered amount of oil from the pressure in the water tank. The water is fed by the pressure of the steam. An extinguishing valve-"E.V."-shuts off flame when propeller thrust ceases. (Mechanism not shown.) Tie rod inside of tank is not required. This system lightened up a bit should fly a large model OK.



This Groves steam engine is a classic example of the mushroom valve engines which many experimenters built in the early 1900s. This was one of the more successful of the lot. The light weight sheet metal crankcase resulted in a much lighter weight engine than engines which had cast crankcases.

The drawings are actual size or full scale. The cylinders are shown insulated with thin wood strips wired in place. This insulation or lagging, as it is called, improves the efficiency of the engine & it tends to prevent condensation in the cylinders.



The crankshaft is made in the usual fashion with the main shaft in one piece. After the long crank pin is parallel with the shaft & the assembly is brazed or silver soldered, the shaft between crank throws is carefully cut out. Then the extra length of crank pin is removed.

The crank throws may not be sufficient to fully balance piston & rod assemblies but they help.

The valve box is one of the critical areas. The angles of the notches & the windows are key factors in making a good running engine. Then these mating valve surfaces should be lapped to 100% contact. This should be checked by the use of Prussian Blue paste or some similar material until 100% sealing contact is evident. Pressure in the valve box above the valve maintains the valve in contact with the valve face.

I do not like the bent connecting rods. Perhaps some brave soul would like to use straight rods. The cylinders would have to be offset. To do so would require that the crankcase would have to be lengthened 1/16" on each side.

The drag or friction of the 6 piston rings may discourage the engine from running at slow speeds at least until the engine has been well run in.

Could there be a steam engine in your future?

Early Steam Engine Design for Model Airplanes.

This 7 cylinder rotary engine drawing appeared in the June 6, 1912 issue of The "Model Engineer & Electrician." (English) It had unique features, some of which were of questionable virtue.

There was no crankcase. The cylinders were supported solely by the "air" pipes on one side. The pipes would need to be extra heavy in order to withstand the bending stress which the off center mounting would produce.

The propeller was mounted on the back side or right hand side of the engine. This would make changing the propeller a major operation!

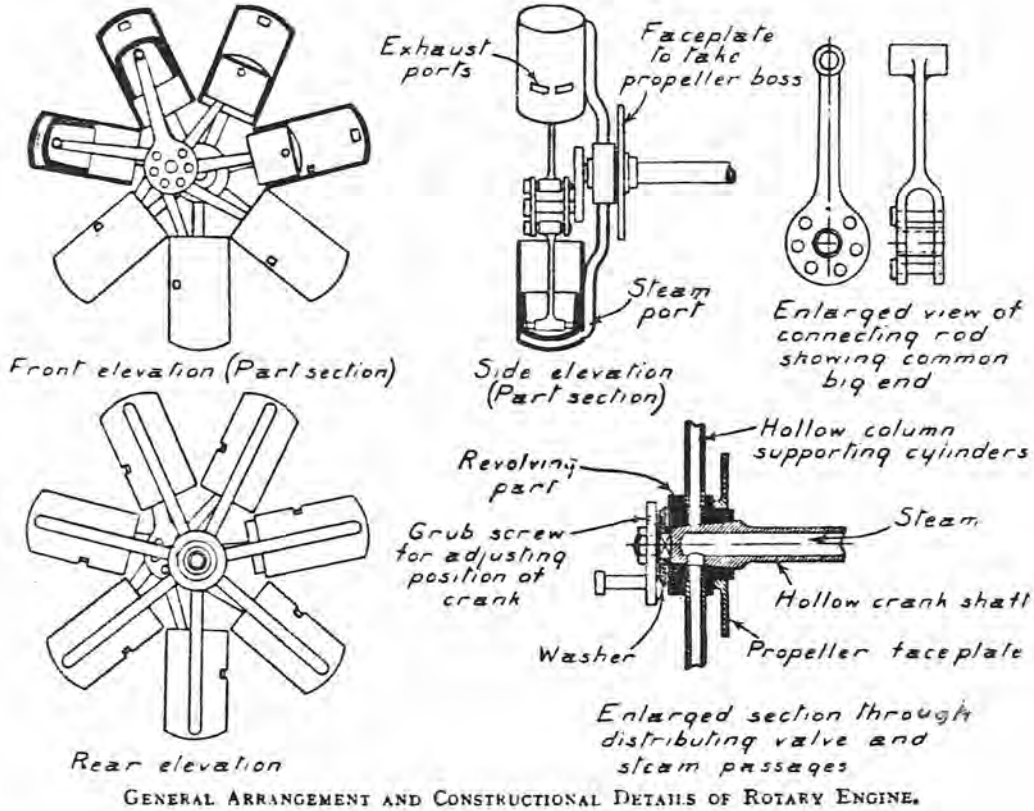
The crank angular location with respect to the valve ports was adjustable by means of a "grub" screw or set screw. This screw could lock the crank in any desired position.

The master rod, shown at the 11 o'clock position, supports the other 6 connecting rods within a "U" shaped end, on auxiliary pins.

The steam is delivered to the tapered valve & bearing through a mating tapered hollow stationary crankshaft. The exhaust steam is vented to the atmosphere through ports in the cylinder walls. The ports were located at the bottom of the piston stroke.

A longer length of taper on the valve & shaft along with a little less angle of taper would seem to increase the wearing life of these parts. It would also reduce air leakage due to a longer path. Five or even three cylinders would produce more power than most model airplanes require for flight. A lot of spinning cylinders however seems to have more eye appeal! Eye appeal does not make the plane fly.

The original 1912 article devoted considerable space to comparing the merits of the rotary engine, particularly the weight, with in line automotive type of engine cylinder arrangement.



General Arrangement and Constructional Details of Rotary Engine.

Results of SAM Champs COMPRESSED AIR Event for the Banaszak Trophy

1976	Dayton, Ohio	1. Tim Banaszak	Hobart	Exact
		2. Karl Speilmaker	Hobart	times
		3. Fred Collins	Adams	unavailable
1977	LasVegas Nevada	1. Tim Banaszak	Hobart	
1978	Cherry Hill, New Jersey, Coyle Drop Zone			
		1. Karl Speilmaker	Hobart (Banaszak-	236
		2. E. Novak	Hobart (=proxy.)	173
		3. Tim Banaszak	Hobart	144
		4. John Stott	Camm	82
		5. Fred Collins	Collins	29
1979	Salt Lake City, Utah	1.Karl Speilmaker	Hobart	132
		2. Tim Banaszak	Hobart	127
1980	Dayton,Ohio	1. Danny Sheelds	King Burd	187
		2.John Stott	Camm	168
		3. Anthony Italiano	Italiano	125
		4. Karl Speilmaker	Hobart	123
		5. Tim Banaszak	Hobart	121
1981	Taft, California	1. Nick Sanford	Sanford	229
		2. Tim Banaszak	Hobart	120
1982	Westover Field,Mass.	1. John Stott	Camm	227
		2. Danny Sheelds	King Burd	165
		3. Loren Schmidt	Solenberger Special	149
		4. Karl Speilmaker	Drone	145
		5. Chet Bukowski	Bukowski	133
1983	LaJunta, California	1. Tom McCoy	King Burd	94
		2. Tim Banaszak	Drone	37
		3. Karl Speilmaker	Drone	16
1984	Bong Field, Wisconsin	1. Tom McCoy	King Burd	87
		2. Karl Speilmaker	Drone	76
		3. Ed Konefes	Konefes	11
		4. Tim Banaszak	Drone	5
1985	Madera, California	1. Bert Pond	Bottle Baby #2	49
		2. Tim Banaszak	Drone	18
		3. Nick Sanford	Sanford	4
1986	Westover Field,Mass	1. John Stott	Camm	207
		2. Karl Speilmaker	Drone	138
		3. Ed Konefes	Konefes	82
		4. Tom McCoy		43
		5. Robert Pattison		39
1987	Seguin, Texas	1. Bert Pond	Bottle Baby #1	
1988	Lawrenceville, Illinois	1.Jim Noonan		

A.M.A. Nationals. McCoy-Pond Trophy for COMPRESSED AIR Models

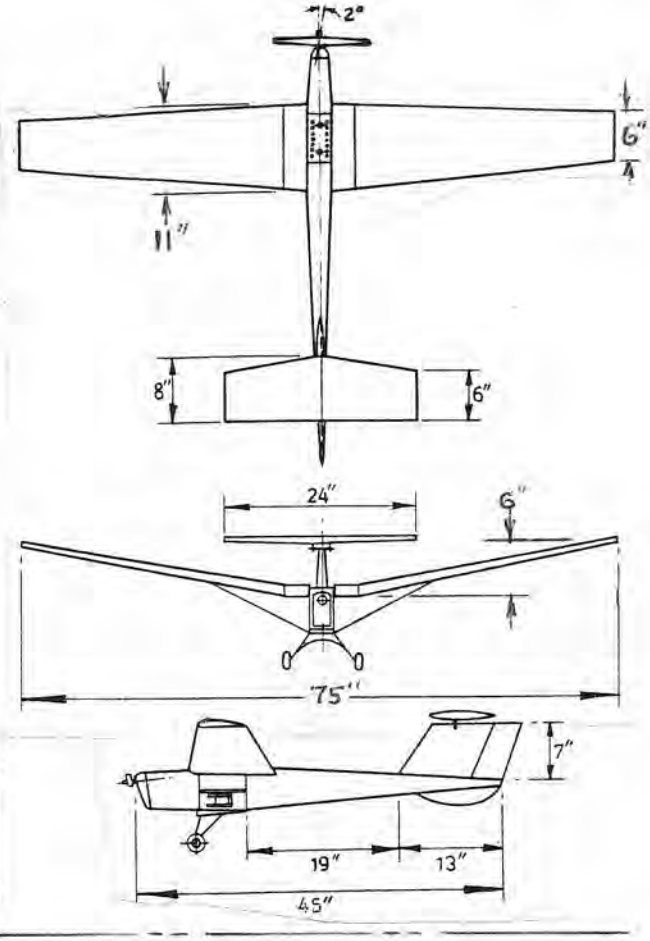
1987 Lincoln, Nebraska 1.Donald Lockwood (Proxy by Carlson).

MISCELLANEOUS NEW ITEMS:-

New Italian Model. A ready made model powered by COMPRESSED AIR has made an appearance in Europe. The motor, tank & propeller are plastic. The wings & tail surfaces are balsa sheet. A tail boom of obechi wood is cemented to the tank & supports the tail surfaces. The tank at 760 cubic centimeters, which is just a bit over 3/4 of a liter, even has a pressure relief valve set to a 7 bar limit (102.9 psi) The engine bore is .3937" (10 mm.) & a stroke of--.31496" (8mm.). The motor weighs .4 oz.(7gm.) The valve has a unique feature in that a spring on top of the piston acts as a pressure regulator because it allows less time of air admission with high air pressure & a longer time when air pressure has reduced. This results in increased duration. The propeller is 6.6" (179 mm.) in diameter. Duration at 7 bar is approximately 60 seconds. The wing span is 35-1/2" (90 cm.) The length is 25-1/2" (650 cm.). Weight of the entire model without the weight of the pressure air is 4.6 oz. (130 gm.). The power plant complete with a motor tank, propeller, flywheel, decals, nut washer & instructions, plus a pump and connection tubing all in a neat bubble pack is obtainable separately. They have named the model "Jonathan" model.

A Modern Steam Model. Steam is not dead! October 1967 issue-Aeromodeller printed a plan of the "Comet", a steam powered model which had made flights & was acclaimed to be the most laudable model of the year. 22 years later the latest offspring has two channel radio control, a 5/8" bore & stroke & double acting single cylinder engine with a three fold increase in propeller thrust. The weight of the power unit assembly which includes the propeller, cowling engine, boiler & the landing gears is 2 pounds. The total weight dry of the plane is 3-1/2 pounds. The power run is two minutes during which the model climbs rapidly with an average total - of 5 minutes. Complete plans will be found in "The Model Engineer" magazine -3 issues-5 May; 2 June & 7 July 1989 (English M.A.P. Magazine.)

William H. Phillips Compressed Air Model. Mr. Phillips provided a plan of his new compressed air powered model which has been included in the plans insert-rear of the book. Mr. Phillips has joined 2 two liter plastic bottles providing a generous air supply for long flights. The plans show no landing gear so Mr. Phillips has added rub strips on the bottom of the bottles to prevent harm to the pressure bottles. In addition he used a folding propeller in order to minimize harm to the engine, propeller & mountings.



This quiet model which emits neither noise or oil nor smoke is the model to retain the use of flying fields-a problem with many model airplane club. You should enjoy building and flying Mr. Phillip's model plane.

S.A.M. RULES FOR COMPRESSED AIR MODEL COMPETITION

S.A.M. compiled rules as follows in order to encourage competition flying of compressed aircraft. These rules were dated February 1975.

I. Power-

A. Compressed air -(C.A.)-motors driving a propeller shall be only acceptable power source.

1. Compressed air shall be defined as free atmosphere compressed by any suitable means and used at or near ambient temperature.
2. In interest of safety a working pressure of 150 lb. per sq. in. will be maximum allowed.
   a. Also intent of rules is to limit C.A. motors to types which can be made in a home workshop.
   b. Also intent of rules is to ban power plants of CO_2 type
3. Compressed air motors for this event shall not be limited in displacement, number of cylinders, or air reservoir capacity except that total weight must not exceed limit set for free flight models by rules of Academy of Model Aeronautics.
4. Propellers may be of any type or configuration except they may not be free wheeling or folding style.
5. Compressed gas other than air such as nitrogen or helium may be used if available to all contestants at a particular meet.

II. Aircraft-

A. Models may be antique design, modern or original.

B. Models will not be restricted in size, weight or area

Since 1975, the rules have been further simplified as follows:
S.A.M. COMPRESSED AIR RULE- Any model (may be original design) powered by a C.A.motor (no CO_2engines allowed) is eligible. Maximum pressure is 150 lb.per sq. in. Models must R.O.G. Three best flights score.

In other words,any compressed air model which can R.O.G. using not over 150 lb. pressure can compete. What could be more simple?

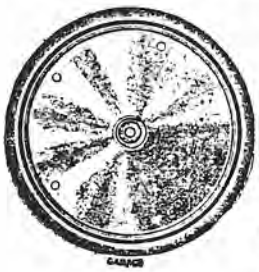


..dusting his COMPRESSED AIR model planes carefully

This composite advertisement of Gamages depicts a most interesting group of COMPRESSED AIR powerplants & model planes. The upper wire wound unit is listed for engines of 2,3,4,5 & 7 cylinders. The 5 & 7 cylinder engines are ball bearing equipped. The twin tanks on the 1913 Canard biplane are a bit novel in that this ship won a contest place. The engine on the bottom tank unit is a rotary engine but the propeller is NOT attached to the crank-case. The propeller is rotated by a gear system about the stationary shaft. The cylinders oscillate & the air is fed through hollow connecting rods!

GAMAGES, the Pioneers of Model Aviation

STAMPED ALUMINIUM WHEELS.



With brass axle bushes.
1½ in. diam. **6d.** per pair.
2 in. ,, **9d.** ,,

"Shaped" Carved Blocks
for making carved propellers.
8 in. **8d.** 9 in. **9d.** 10 in. **10d.**

Birch Propeller Blanks.
12 × 1¾ × 1/16 ins.
Price **1/3** dozen.

Steel Hook for Rubber Motor, with Screwed Spindle and Nuts to take Propeller, **3d.**

STEEL EYEBOLT.



With Nut and Washer for Model Aeroplanes. Size as illustration.
4d. each. **3/6** dozen.

4-Bladed Propellers.

6 in.	7 in.	8 in.
2/6	3/-	3/6
9 in.		10 in.
3/9		4/-

Para Rubber Strip
for Aeroplane Motors, ⅛ in. wide,
12 yards **1/-**
50 yards **4/-**

Collets, 2d. doz.

Brass Bearing Brackets 2d. each.

Ball Thrust and Spindle with Hook, **1/-** each.

Oiled Aero Silk, 30 in. wide, **4/-** yard.

Rubber Lubricant in tubes. **9d.** each.

BRASS WIRE STRAINERS



with Steel Screws for Model Aeroplanes.
Breaking strain, 200 lbs. Size as illustration.
4d. each. **3/6** dozen.

AIR SCREWS.

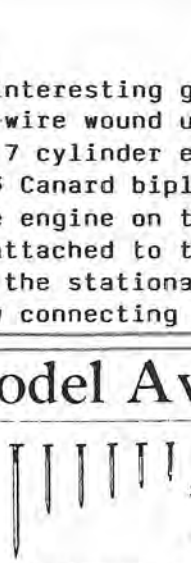


Right or Left Hand. Post free. Prices.

6 in.	7 in.	8 in.	9 in.	10 in.	11 in.	12 in.	14 in.
1/-	1/2	1/4	1/6	1/9	2/3	2/9	3/6

16 in., 4/- 18 in., 6/- 20 in., 8/-

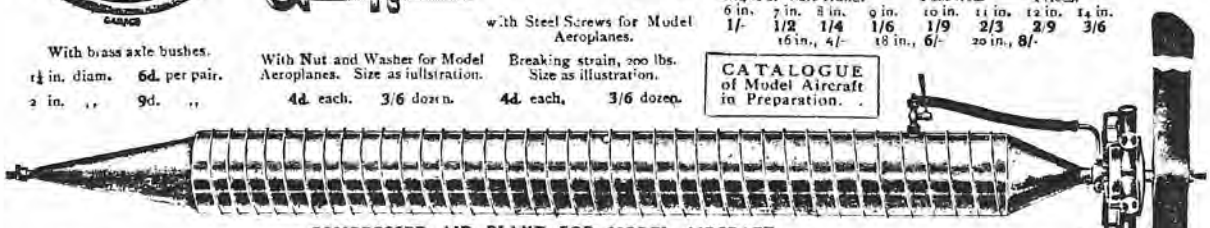
CATALOGUE of Model Aircraft in Preparation.



COPPER MODEL-MAKING NAILS.
Much superior to iron. Do not rust.
Price **6d.** per packet.

CROID, Liquid Glue, as used in building full-size machines. **6d.** tin.

Wood in 3 ft. 6 in. lengths.
¼ × 1/16 **2d.** length.
¼ × ¼ in. **3d.** ,,
¼ × ⅜ in. **3d.** ,,
¾ × ⅜ in. **8d.** ,,



COMPRESSED AIR PLANT FOR MODEL AIRCRAFT.

2-Cylinder Rotary Engine only, weight 1 oz. .. **5/-**
3 ,, ,, ,, ,, ,, 1½ oz. .. **10/-**
4 ,, ,, ,, ,, ,, 2 oz. .. **15/-**
5 Cylinder Rotary Ball-bearing Engine only, weight 4 oz. .. **50/-**
7 ,, ,, ,, ,, ,, 5 oz. .. **75/-**
Propellers extra.

Armoured Containers for above. 18 × 2 in. weight 5 oz. **10/-** 30 × 2½ in. weight 10 oz. **25/-** 38 × 3 in. weight 13½ oz. **30/-** 24 × 2 in. weight 6 oz. **15/-**

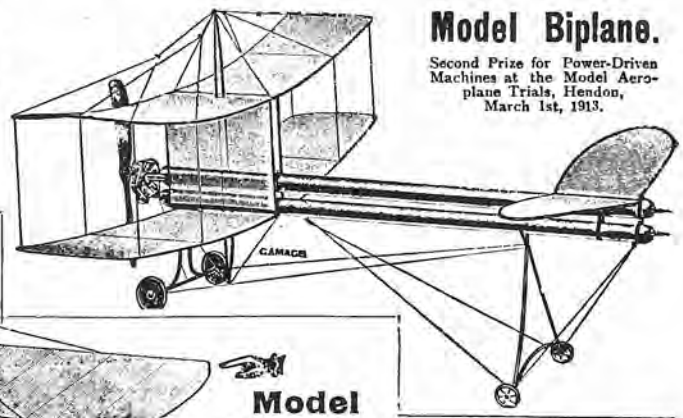


Driven by compressed air. Beautifully constructed of aluminium tube steel wire and silk planes. 5-cylinder rotary engine, with 18 in. propellor.

Will Really Fly.

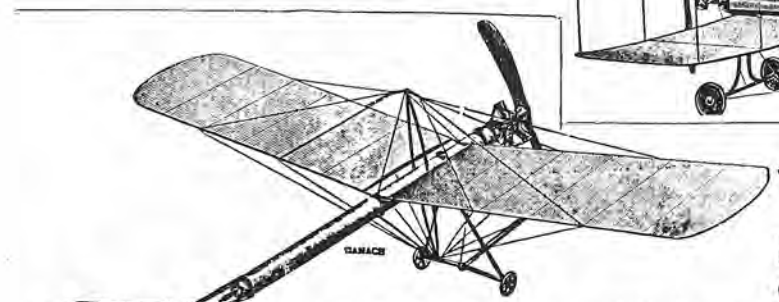
Price .. **£10 10 0**

Complete with Pump.



Model Biplane.

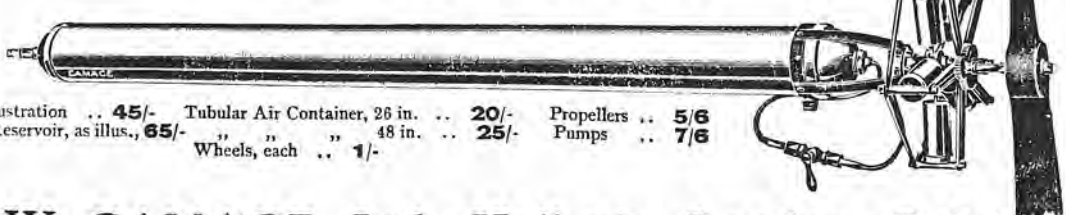
Second Prize for Power-Driven Machines at the Model Aeroplane Trials, Hendon, March 1st, 1913.



Model Monoplane.

Canard Type Monoplane, large size .. **£7 10 0**

Driven by 5-Cylinder Rotary Compressed Air Engine, scientifically constructed of Aluminium Tube. Silk planes, spring landing chassis. Duration of flight, approx. 30 seconds.
Speed approx. 25 m.p.h. Price .. **£6 15 0**



Motor only, as illustration .. **45/-** Tubular Air Container, 26 in. .. **20/-** Propellers .. **5/6**
Motor with Air Reservoir, as illus., **65/-** ,, ,, ,, 48 in. .. **25/-** Pumps .. **7/6**
Wheels, each .. **1/-**

A. W. GAMAGE, Ltd., Holborn, London, E.C.1.

BROWN JUNIOR®

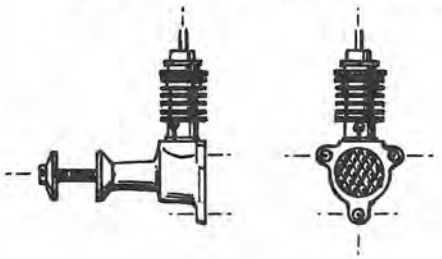
BROWN JUNIOR MOTORS, INC.

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— Model Aircraft Engines —

CAMPUS A-23

PEANUT CO_2 ENGINE



FULL SIZE

USE THIS DRAWING TO HELP PLAN MODEL INSTALLATION

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THE HOOSIER WHIRLWIND COMPRESSED AIR MOTOR

WT. ONLY ⅞-OZ.
3-IN. DIAMETER
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STRONG AND POWERFUL

Counter balanced steel crankshaft. Unique. Flies 4½ ft. to 6 ft. models. Finished parts, easy to assemble, $2.90 postpaid. Completely assembled and tested $4.90 postpaid. **COMPRESSED AIR TANK** — Gnatweight, seamless, high pressure, 3" dia., 30" long, $7.00 postpaid. 24" long $6.50 postpaid.
MOTOR AND 24" TANK COMBINATION OUTFIT — Weight complete only 8¾ oz.! Special price till March 1st only. Send this ad, $11.00 postpaid.
COMPLETE K.F FOR 5 FT. COMPRESSED AIR MODEL with blueprint less tank and motor $4.90 postpaid. Have an air model for your next National Model Airplane contest. Order today! Be sure and inclose only money orders or drafts.
COMPLETE KIT FOR "C" EAGLE MODEL with wire parts, realistic featherweight celluloid wheels & large blueprint $2.75 postpaid. With carved propeller $3.50 postpaid.
SEND 10c AT ONCE FOR A NEW ILLUSTRATED LIST JUST OFF THE PRESS showing all the latest and best materials as used by recent National contest winners of trips to Europe, etc., with surprising low prices on the best materials.
Schools, clubs, dealers write for terms. "Model Airplane Experts of Today are the Aviation Experts of Tomorrow."

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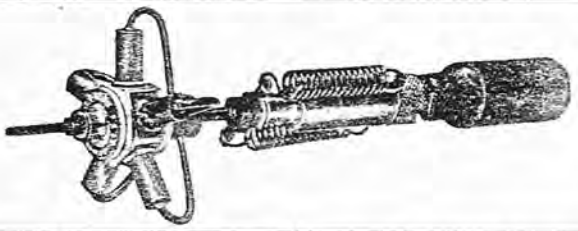
MODEL AIRPLANE MOTOR
Compressed air. Only motor of kind on market. A powerful job, fly 4 to 6 ft. wing span. Blue prints. Send for circular. **$4.50**
Amalgamated Sales & Service Corporation
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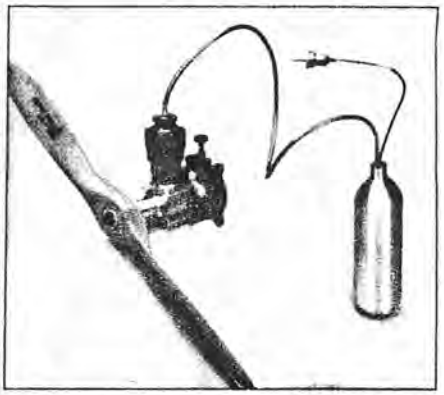
A recent ready made model - a COMPRESSED AIR toy- at the Nürnberg Toy Fair.

The Smallest and Lightest Motors Known Are the

Moteurs Rotatifs Fieux



Works and Offices 57, rue Cambronne, Paris, France



The Davis conversion mounted on a Cox .02 with an 8-6 prop.

CATALOG - (Availability & prices subject to changing conditions.)
* Add 10% to all items, except lists, for handling.*

1. Book-"The Aeronautical Work of Lawrence Hargrave"-copy of 40 page book describing Hargrave's experiments with expansion engines & flying models in the 1890s. (Original had 1/2 page clipped.) A very fine book. Special------$9.85

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