Extracts from

Aerial Sport

How and Why I Built the Pou-du-Ciel

Henri Mignet

(translated by Jason R. Fruit)

2019

Contents

Translator's Note

I have not presented Henri Mignet's little book in its entirety, but *ars longa, vita brevis*; I want to move on from translation to build the little airplane about which I have read. I must apologize for this failing, however, because his writing is an absolute pleasure, and his ideas are engaging and inspiring.

If you find errors of fact in my translation, please contact me at `JasonFruit@gmail.com` with improvements, or submit a pull request via `git` at `https://github.com/JasonFruit/sport-de-lair`. If you find stylistic improvements that could be made, feel free to make your own translation. Better yet, go build an airplane.

1985

The previous edition of this work was published in 1937.

It sold out quickly. By the end of the war, it was almost impossible to procure a copy.

Much time has passed. Much has changed. Some aeronautical disorder has given way to a new order — which is not necessarily an improvement.

Henri Mignet, fleeing the memory of a terrible tragedy, hung his hat in every corner of the world, leaving his faithful to preserve the Flame.

During his absence, some amateurs, attracted to aeronautics by his Pou-du-Ciel, relaunched the movement he had started, forming the *Réseau du Sport de l'Air*, the successor to the RAA.

Many productions saw the light of day — especially classic aircraft, these last sometimes with the financial encouragement of the state.

The results were so remarkable that these same amateurs at times became artisans, and even industrialists!

In this manner was our current light aviation born.

When the Patron Saint returned home in 1958, he brought with him wonderful memories and spiritual treasures. But also, he brought back notes for projects being carried out by his successors.

Henri Mignet is no longer with us.

But here, thanks to some good friends, and thanks too to the *Réseau du Sport de l'Air*, just mended, barely completed, is

LE CHER BOUQUIN

Pierre MIGNET
Les Pierrières
October 1985

Chapter 1

HOW I BUILT MY POU-DU-CIEL

If you can nail up a shipping crate,
You can build a Pou-du-Ciel[1].

What is an aircraft?

- A body with tail-feathers, pulled forward by a propeller, securely suspended under a bearing surface that it pulls along.
- A chain, the many links of which must all be equally solid. If only one link gives way, the system will cease flying.

[1] I hold this slogan as necessary criticism of my opponents. Is it a joke? — No! It's a skillful camouflage...I needed this propaganda, without which my book would have been dull, sad, turbid, and monotonous; without which I would not have started anything; without which 500 future airmen would not have built their airplanes; without which the public would never have seen at the *15^e Salon de l'Aéronautique 1936*, two galleries of the *Grand Palais* occupied by 31 light aircraft (Brochet, Sfan, Bassou, Voliand, Bécheraud, Trébucien, Taupin, Cri-Cri, Léopoldoff, Mauboussin, Moustique), dominated by a squadron of 3 of the latest Pou-du-Ciel models!
(As for building a solid packing box, it's harder than you think!)

- A combination of simple elements that appear complicated.
- An ordinary structure, of no precise adjustment, which still requires that everything should keep its shape.

1.1 Material

The forest. A tree.
Cut down. Sawn. Split. Dried.
Carpenter - Band saw - Planer.

A straight board, squared up, shining, veined with pink, supple, stiff, light, fragrant. This material is no longer merely a *tree*. Cut to length, bent, glued, nailed, sanded, varnished: now here is a part of a whole, filling a void, a specific destiny, occupying a particular place in the world, fulfilling its proper role.

It commands rapt attention: we look at it, we touch it, we evaluate it, we care for it. It has *personality*. It did not exist heretofore; now it is born, it *is*.

It has life, like a painting, a work of art. It will have adventures. It will age, it will die — in an attic, at the junk shop, or in an accident — like a being given life in a bed, in the hospital, or in the railway — like you, its creator.

Does it not spring from your blood? — Bought ready-made, what would you see in it? A commodity, nothing more. But in this, if it were exchanged for money, marketed, sold, or given away, you would lose a piece of yourself...

You have no emotional attachment to a plaster-of-Paris statue, to a car, stamped out by machines tended by bored employees. But you have affection for what is lovingly carved by a craftsman, because he placed his soul therein.

Having bought a tool, whatever object, I do not enter into its actual possession, I do not become attached to it, except after disassembling, improving, and reassembling it correctly, giving it a state of completion that is incompatible with mass-production, where the distracted hand of the worker refuses to honestly finish it.

Is there another piece of the airplane that is more attractive than the propeller, the beautiful propeller with a slender curve that you have so carefully sanded and varnished? It is a symbol, it is a sculpture in wood, personifying our object: the emblem of Aviation!

The material we craft is alive and sensitive, entitled to a *caress*.

What will be its destiny? Over what clouds, what valleys will it soar? To what regions will I be carried, reclining on its cushions, belted to its seat? — It bears, latent, a full slate, a lifetime of adventures.

From just a piece of wood it takes shape; its fate, still unknown to me, is there, before me, under my hand, invisible, as I father it; I am author of a life whose course I do not know, to which my body will be bound in an intimacy sometimes joyous, sometimes hard and serious!

> A pretty story? — A reality.
> Imagination? — Real-life adventures!

The material thus shaped *lives*. It will live more fully under the effect of the engine. It will age with use, it will "grow up"; the sides of the cabin will be weathered with oil, blackened by exhaust, grass-stained... the cabin soiled, worn, scuffed by shoes, blackened at the back, pierced with now-useless holes, marks left by past experiments... Flight, adventures, patched up bruises — this packing box evinces the accumulated past. Not everyone has such a full life! Have a look at some old crate at the airfield. Can't you feel the charm, hear the stories that emanate from its decrepit frame?

Respect. — So, a kind of friendship — I almost said, love — makes you feel that the materials for this special construction must be touched only with clean hands. Respect the material. Do not brutalize it. Wood is not only of the tree: it is a longeron, a rib. Look at it closely; see if it is healthy.

Smoothness on the outside, detailed on the inside. Finish your pieces well; round over the sharp corners, scrape away the spots. Let the viewers congratulate you on your work.

The amateur is like the sailor: He is a jack-of-all-trades, universal. Overmuch mathematical baggage is not necessary to him. His handyman skills are enough to salvage delicate situations. Above all, he has a huge dose of “common sense”. For this, there is no school. With a little money and a lot of common sense, the amateur who knows which way to turn a nut will succeed at this too.

1.2 Humility

The processes I outline here spring from my observations and the outcome of an amateur’s life work: they are made for amateurs.

I have intentionally adopted simple, rustic methods, to avoid professional techniques which would scare off the amateur or needlessly exhaust his time and patience.

Some will find our methods rudimentary — "just do this, do that", you will be told! Avoid those people like the plague, and beware anyone who believes they have some mystical secret!

I do not give you a choice of several models. In my previous edition, I displayed my "Pou-du-Ciel" still quivering from its first ten hours of flight. The same was exhibited at the 14^{e} salon de l’Aéronautique after 60 hours. It then had its feathers plucked and was modified, transformed in search of progress. I have refined the details, but the formula has remained the same. I have some 300 hours of flight in the Pou-du-Ciel. My latest model does not have much over one that is 100% from the book.

Life has forced industriousness on me.

The inadvertent advertising that my dear little book created among the amateurs has raised in the general public a feeling of clientèle, setting for me certain conditions. The "Pou-du-Ciel" has excited aviators and potential buyers. But they dream of performance, of comfort; they want Aviation, the Pou-du-Ciel way. I’ve searched for it — I’ve found it — but I can no longer be merely an amateur.

Will I, in this new book, describe to you not only the Pou 100% by the book, but also the Pou two-seat sedan? And then the Pou-Bébé of less than 100 kilos? You, dear amateurs, you are good comrades; but this little book is read also by less-good guys who will hurry up and build a counterfeit Pou-du-Ciel, to profit from my labors, at the cost of my little secrets and my reputation.

These new devices that I prepare and have already flown, what do they do more than the Pou-of-the-Book? They fly faster, they climb higher... And then? They are made to be sold, but in the state you are in, you, amateur builder, they would not give you more satisfaction. New as they are, their construction by non-professionals would risk danger. The Pou-of-the-Book has already had misfortunes... what would happen if I provided you with new models? There are amateurs who would mix everything up, the government agencies and trade organizations that protect the original formula would be overwhelmed... the opposition journalists would cover it all in their sticky ink... We would not see anything at all.

My honor is preserved by keeping to the Pou-of-the-Book. The friendly help of the Ministry is not compromised, the troublemakers have no reason to open their big mouths. Amateurs will soon be able to escape the racetrack and Mignet the industrialist will not have completely to shed his amateur's skin[2].

In doing this work, I tamed the beast as well as I could. The Pou-du-Ciel of 1936 is almost a new aircraft, as it has improved its flying qualities beyond its available power, as well as its comfort and stability.

Do you want to fly like me? Build according to the book, changing nothing.

Don't worry your head. Save your own innovations for later, after you have 10 hours of flying. You will judge your inventions from a very different angle then — believe me!

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[2]The meaning of this passage, *«Les amateurs pourront bientôt s'évader des tours de piste et Mignet l'industriel n'aura pas complètement dépouillé la pelure de l'amateur.»* may have been mangled in translation.

1.3 Prudence

All that flies must necessarily, be light — granted.

One day when you repaint your craft, you will disassemble it. Out of curiosity you put the pieces on the scales... Five, six kilos too much! You have made additions in recent flights!

From this day, the obsession grabs you, tenacious... You have a horror of weight. It becomes a mania! And you weigh, you streamline, you lighten...

Suddenly, reality hits: "It's crazy! my craft may have become fragile! I'm losing my mind... I do not know anymore..."

And you are caught between hammer and anvil, between file and wood. — Too heavy? Too fragile? — Dilemma!

Lightening a device does not just mean scraping away everything that doesn't contribute to safety. It is not enough to turn a plywood board into a colander, or to chamfer the corners of all square pieces: This is called "filing grams" with a nail file.

The rational solution lies in a judicious, thoughtful plan, avoiding complexity, reducing the number of important pieces. We then save the kilos by tens. These few parts, then, can be reinforced: they only weigh a few grams.

1.4 Two-seaters

You have not built yet. You admire aviation from a certain perspective. You think: "I will build a two-seater right away!"

Ah! Poor amateur! Poor imaginative! How many times have I been written to about this damned two-seater! Everyone dreams about taking his girlfriend up before he knows if he can rise above the daisies alone!...

Amateur aviation is a solitary sport, like horse-racing. The 40 kilo jockey will always beat the fat one.

See the big touring two- or three-seaters prepare for a trip. It's like a free balloon: Everyone scrimps on luggage: we have so quickly accumulated 50 useless pounds! We can trade our parachutes for 30 liters of extra gas...

Aviation is primarily a problem of weight. A two-seater? You'll never fly in mono!

The two-seater will require 35 to 40hp, twice as much fuel, important fees... You won't find a suitable engine. You are stuck with a single-seater... you can't avoid it! I do not want to hear any more about amateur two-seaters. I will not answer!

You will build a flying machine.

First, you will take off the ground. It's easy. — Then you rise above the fields, one or two meters. This is the big joy. — Then you go up. Distant hills rising behind your familiar horizons. The top of a tree goes under your wheels. The village steeple is lower than your horizon... The sky is under your butt!

Well ... what if your wings were to break at that moment? Wouldn't you feel a little thrill in your heart?

Me, I felt it. I do not feel it anymore. Not because I got used to the danger, but because I superabundantly reinforced the points that worried me. You will also avoid this unpleasant thrill if you follow the directions of my book exactly.

Correspondents have sometimes asked me for full-size drawings, or large scale blueprints, like they use in factories. What good would it do? Everything is specified already in the small ones! If you can't read and understand them, you don't have the skill for this. Do not begin building — you will hurt yourself.

1.5 Materials

You will needlessly look for special "Aeronautical" raw materials here. I chose a wood that is found in all lumber yards and carpenters' shops: the fir tree of our furniture and our roofs. The dimensions used are in agreement with its strength. If you find American wood, spruce, Oregon pine, all the better. Similar weights, increased strength — do not change the dimensions. You would save a few hectograms… big deal!

For metal, I put myself in the shoes of the village amateur. I chose mild steel sheet, because it pierces, files, and bends without special precautions. I strongly reject the use of more or less hardened aluminum in the vital fittings, *eġ˙* in the bracing of the wings.

A single metal for the amateur: sheet metal; tubes; rods drawn or threaded; bolts; all in mild steel from any hardware store.

The mild steel sheet joined to wood by small bolts will endure vibrations and resonances indefinitely.

Long live steel! Long live wood!

1.6 Accessibility

The Pou-du-Ciel is a simple design.

The most basic prudence suggests that you should entrust your life only to a simple mechanism — simple and verifiable.

A bolt a nut, a pin, when it is accessible, can be checked. It will not shirk its duty. Hidden, the best-secured piece will eventually come loose — and your goose will be cooked. We may find the explanation, but it will be too late.

The entire mechanism of an aircraft must be visible, accessible, verifiable, easily removable. Then, you will live. Otherwise, it will kill you.

This is a law of Nature.

I did not cowl my engine; I placed all my controls externally; my braces are at my fingertips. The fuselage is an empty box. Inspection is possible.

1.7 Regulation

I do not know the future, and neither do you. Anything could happen, even kindness from the government.

The *Bureau Veritas* controls the "Pou-du-Ciel". The *Services du Ministère* will make its decision. The book currently serves them as a basis. If you have not followed my instructions strictly, you may be refused

permission[3] to fly.

I urge the official inspector to examine your device (which will not yet be covered, of course) to see that it is *according to the latest requirements* for the correct installation of the braces, the wing pivots, joins of the covering, choice of materials, and the wood used: *iė˙* no knots, straight grain, *etc*.

Any permission to fly must be categorically refused to the stubborn mule who chooses not to follow the book.

The inspection of the Pou-du-Ciel is too easy for a catastrophic defect to go unnoticed, and its flight balance is so straightforward that a close examination will cover the inspector's responsibility.

The fruit of long experience and 150 examples having flown is this: **The Pou-du-Ciel does not break in the air**.

1.8 Patent

When an inventor has created a new trick, he makes its paternity official by providing the Ministry of Commerce and Industry an exact description and a careful explanation. If it's really a new trick, this will allow the inventor to claim priority. Should a dishonest industrialist or someone simply unaware of the prior art of the patent,

[3] M. Mignet says, "the right to fly," but no-one can remove from you a right. They may deny you permission, but *you still have your rights!* — Translator

build and sell a realization of the trick without the patentee's consent, the patentee has the right to oppose him a court of law. Occasionally the inventor even wins...

The amateur handyman, passionately interested in a new machine, does not[4] have the right to build it for personal use, even apart from any profit.

The "Pou-du-Ciel" is patented in France and abroad. No manufacturer has the right to sell, without the authorization of the inventor, parts having the character of the Pou formula. Builders and buyers can be likewise prosecuted, sooner or later, when the inventor sees fit to take care of it.

Unusually, I detail in this book the construction of the Pou-du-Ciel for amateurs, and permit him to build one himself, with his own hands, or using the suppliers whose addresses I indicate. If he complies with these conditions, the amateur will not be pursued legally. He should not look at these restrictions as some commercial scheme. "My" amateurs know me; the "others" can check with the suppliers. It's only natural for one who is honest with others to continue working with those who have worked to his benefit.

1.9 The Author's Responsibility

The Pou-du-Ciel cannot break in the air. This is meant with regard to normal use as a vehicle. Whether going by car, bicycle, boat, horseback, etc., there are two ways to take a trip: carefully, or recklessly. Human foolishness, when unleashed, respects neither age nor fortune, nor race, nor any other limit. Each does as he pleases; each pays the consequences. If you are cautious, as I am, if, like the sailors and airmen of certain companies, who rightly understand the possibilities of their equipment, and you fly when the weather is fair, you will never get hurt.

The risk is infinitely less than on the road.

[4] In France, at least, this was apparently true.

Under these conditions, I take the moral responsibility: In conscience I know not to engage in folly. I flew. My machine is solid. You can do the same. I think I have everything planned, everything arranged so trouble will not occur.

Many clubs, seduced by the simplicity of primary gliders, wanted, from motives of economy and sportsmanship, to build their machines themselves. Apparent simplicity. Who could have known before the fact that such a very hollow airfoil would cause the wings to snap? That piano wire constituted an insufficient brace?

Many accidents happen, including the most ordinary: a glider's wings can collapse in flight when the pilot, being towed by winch, pulls the release handle too sharply. Thus Ferrero was killed in Tunis, in a primary glider, in November 1933 — eight days before experiencing his HM.8. Who could imagine, to see it so well finished, so beautifully curved, that such a perfect glider would spin in in a flash. . . ?

It is incontestable, in France as much as in Germany, that, in gliding clubs, **there are many accidents** and **there are many injuries**.

The particular design of the Pou-du-Ciel and its construction put it in an totally different class. I know what I did. I know what it can do. I leave it to the future to show that it is, *of all current aircraft*, the least deadly.

But I will have no regrets, no sadness, no emotion at all if I learn that you have hurt yourself by acting foolish. This no longer concerns me.

1.10 To Fly!

But you are wise. Your personal ideas set aside, you say, "Mignet flies. I want to imitate him, and soon, fly better than him. To avoid delay, I will copy his machine exactly, to place me on the same level immediately. And then after. . . look to yourself, good fellow!"

The obsession with Air, Space, Volume is as old as mankind. It is an unlimited vista of imagination: everyone wishes to try his own ideas.

The possession of the atmosphere is the most beautiful of man's conquests. Already we have gone beyond Nature on several points. Yet a few secrets to penetrate, and we will have won.

Air travel is the height of diversity. To go by air is the least dangerous and the least expensive of all. It is impossible to foresee the consequences of this novelty on the social economy of the nations... Light aircraft will be the essential mode of transport in the coming new society. They are as powerful and diverse in their mode of action as the medium in which they move, the vast Ocean whose invisible waves flit over our heads.

We are truly on the threshold of the aerial age, and it belongs to the amateurs, thanks to their universal quality as innovators.

Overcoming gravity, moving through three dimensions... What a strange fascination, what a wonderful science! A contest of ingenuities, a rivalry of innovation... A record is broken, the satisfaction of a difficulty overcome. The rival wins? — A thrill of jealousy says in your ear: "Me too — one day, I'll beat you!"

Voilà le S/

Even the smallest accomplishment proves the man. Each one shows his value, each produces a spark. A sensational record, even around the world nonstop, does not diminish the accomplishment of the beginner who, his device just completed, flies for a mere two seconds. It is **he** who built it, **he** who flew it. It is to him, his capable hands, his eyes alight with joy, that the praise redounds!

Voilà le S/

Your "cuckoo" is no longer a simple frame covered with canvas and braced with wires. It is a latent power.

You will shine it, polish your brass turnbuckles. . . you will caress your big propeller, inhaling its odor of varnish. . . You rub down your engine with its deep fins, a thoroughbred of modern mechanics, whose heart will beat at your command, suddenly animating the machine with the personality that belongs to a *living being* endowed with character, which in turn your reflexes must obey. It is your child — and your master.

It is a machine companion that you defend as your own self, passionately loved, far beyond a man's watch or his camera — it is an old adventuring comrade.

Empty dreams? Vain ambitions?

You will have crazy fun! You will learn to manage an engine other than by the throttle: carb jets, spark plugs, mixture, tachometer — all of it. . .

And you will fly for real: Your engine, simple aid, will sustain you under your shining wing. You will live **la Vie de l'Air**, take into yourself the reactions of the atmosphere, deeply, to satiety. Perhaps, meeting eagles in flight, you will try to soar as they do, engine off — will you learn to employ the currents of the breeze?. . .

A formidable future, of which you may, unaware, become a Pioneer. . .

Voilà le S,

Chapter 2

Construction

2.1 Supplies

Obviously, M. Mignet's suppliers from the now-distant past are no longer in business. They have been omitted except where the discussion may have current interest. The list of materials, however, is still of use. — Translator

1. Okoumé plywood

   6 panels 200cm$\times$100cm, thickness 3mm (30 tenths)
   7 panels 200cm$\times$100cm, thickness 1.5mm (15 tenths)

   There is special plywood available, such as 1mm Okoumé and 0.7mm Birch (which costs 60 francs per square meter!). The Pou-du-Ciel does not require it.

2. Stick softwood: Northern fir, Sweden, Oregon pine, etc ...)

   6 5m lengths 15×60mm, or 10 pieces 3m 20cm in length
   10 4m lengths 20×20mm
   50 3m lengths 6×12mm

3. Fabric and dope

Only approved Aviation supplies will do, not the cheaper, flimsier fabric.

100m 40mm pinked tape
30m^2 standard fabric
20L standard dope

If you can afford it, get 40m^2 fabric and 30L dope.

4. Wheels

   A good size is 450×100.

   The Lambert brothers have built a wheel in stamped and welded steel plate with bronze rim, for a 40mm axle, weighing 1kg 600. Equipped with Dunlop tires, it weighs 3kg 700.

   By agreement with me, these same Lambert brothers, who were practicing as amateurs at the time (1936) of the old HM.8 and the Pou-du-Ciel, have produced parts and fittings specially adapted to the Pou-of-the-Book. Ask them for a price. Whoever has not worked metal before will do better to buy his hardware. It will of course be more expensive, but faster and safer.

   N.B. — I do not authorize any other person to sell spare parts, special fittings for the Pou-du-Ciel. The Lambert Brothers manufacture them under my control, and they give satisfaction. *I receive no commission for it.* I warn the amateur against several counterfeiters (who will be pursued one day or another) and sell scrap iron shamelessly shaped, denatured: they are criminal thieves.

5. Hardware

   Seamless drawn steel tubes:

   4m 13×16
   4m 16×18
   2m 16×20

2m 17×20
2m 21×24
50cm 24×27
1m 20cm 31×35
1m 20cm 36×40
20cm 40×44

Also, at your option, the drawbar: 1m 80cm 31×35.

Mild steel plate:

30×80, 20 tenths.
Other thicknesses (15, 10, 6 tenths) purchased as needed.

Drawn mild steel rod: 2m each 4, 6, 8, and 10mm
Threaded mild steel rod: 3m each 4, 5, and 10mm

Steel bolts, with their nuts:

50 5×40
30 5×60
20 6×40

Have a good supply of hex nuts… You won't lose by this — because you will lose a lot of these!

200 4mm
200 5mm
20 10mm lock nuts

Extra flexible steel cable:

10 meters in 5mm. for bracing; also 20 thimbles and 20 end fittings with 2 bolts.
20 meters 2.4mm for controls; also 20 thimbles and 20 end fittings with 1 bolt

No galvanized cable, please. Forget economy — your life is at stake here!

Aluminum:

$1m^2$ 6/10 (rollovers, trim, etc.)
2m 3mm aluminum wire (rivets, floats, etc.)

Nails, steel, flat head:

100g 1×25
100g 1×20
400g 1×15
600g 0.7×8
200g brass, 8 mm.

6. Bungee

   5m 12mm; it should start to stretch at about 38 pounds.

7. Celluloid (windshield, windows, etc)

   One sheet 1m20cm$\times$0.60$\times$1mm weighing 1kg.

8. Glue

   Of course we should no longer use casein glue! — Translator

   2kg Certus brand cold casein glue, powdered, in tins

9. Tubes and light metals

   Aluminum tubes, all thicknesses, all sizes, from 3.5×4mm
   Tubes de brass and copper (pitot and static tubes, fuel lines, etc.)

   Duralumin:

   20 tenths sheet, $50 \times 50 \times 1kg400$
   Tubes of all sorts, in T, L, U, etc. sections

   21×25.1m $=$ 0kg 100
   17×21.1m $=$ 0kg 275
   6×8.1m $=$ 0kg 75

   Expensive metal, and not suited for amateur use in vital parts of the machine.

10. Fuselages, wings, rudders...

    The sale of these pieces ready-made, either whole or in parts, *e.g.* spars, ribs, is unauthorized, except insofar as the advertisement carries the words "under the control of H. Mignet". Anyone unable to build the wood part of the "Pou-du-Ciel" is unworthy of the name, "Amateur" — *Ugh!*

    (M. Mignet offers additional suggestions: a supplier for aeronautical maps and a subscription to the amateur aviation journal «Les Ailes». The translator recommends membership in the Experimental Aviation Association (EAA) and subscription to its publication, Sport Aviation, as the best modern-day substitute for «Les Ailes». — Translator)

Chapter 3

To Work

The amateur is an *enthusiast*, an artist who obeys his impulses.

The amateur wishes to grant himself wings. He would stick feathers on the egg before the chick hatches to speed him along... He will start with the wings!

No! I will subvert this logical order.

We begin with the fuselage!

3.1 Fuselage

The fuselage is built like a crate. But since the plywood cannot be nailed to itself, a pine member is fastened at the corners, as an intermediary which receives the nails, which clamp the faces as they are glued. In this way, the plywood faces are

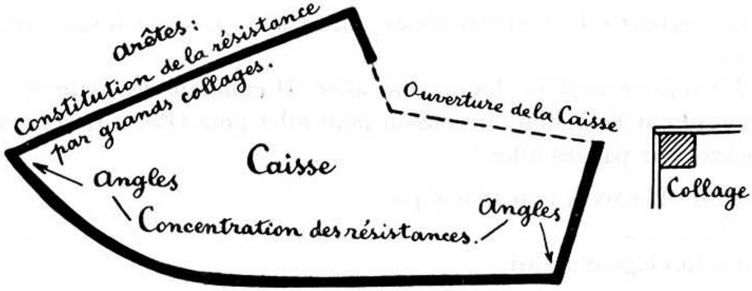

Figure 3.1: The members concentrate the strength of the plywood

joined together not by nails, which is flimsy, but by plenty of glue, which is like welding the wood. When we say, "nail these", glue is implied, wherever wood touches wood. I saw wing ribs without glue, the tips of whose nails too long, so they were folded back on the sticks they had pierced! I also saw a fuselage whose nails, driven from inside the pine members, barely penetrated the 3mm plywood. No, dear child... the head of the nail must be on the plywood side to clamp it to the member!

The pine members concentrate the strength of the plywood, allowing fittings to be attached to the corners of the box where the plywood alone would have only a weak local resistance *(Fig. 3.1)*. These corners are extremely strong nodes which will form hard points for fittings.

The longerons behind the cabin extend its solidity to the rear, and form an extremely rugged triangulated pyramidal structure.

At the risk of being a bit overweight, the fuselage is built entirely of 3mm ply. It will retain its strength.

(M. Mignet gives details about preparation of casein glue, which is

no longer in use. — Translator)

Before using it, examine the wood; it must be healthy. No greenish tinge suggesting the effects of worms; when planed, it should smell of resin. The shavings, twisted like string, should resist traction.

Each member, carefully selected, is held in the vise by one end and twisted along its length. It must not break or crack.

Inspect it minutely: it must have straight or only slightly oblique grain, without knots, splits, or shakes.

3.1.1 Fuselage sides

On a piece of 3mm plywood, lay out the first side according to the dimensions in Figure 3.2. The direction of the grain is indicated by the arrows *f*. Proceed according to the numbered steps: ①, ②, ③, etc.

The dimensions are given in millimeters. Determine the angles using a protractor.

Cut two sides the same with a fine-bladed handsaw.

If the plywood is too small in the correct grain direction, choose a point *p* on the segment *a*—*b* at which to make a glued scarf joint. Temporarily nail through the scarf joint into a wooden piece covered with newsprint, which can be removed when dry.

A longeron 20×20, 2700[1] mm (2m 70cm) is glued and nailed as at ⑫, fig. 3.3. It extends beyond the end of the side by 1900 mm.

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[1] Both here and in the figure M. Mignet mistakes himself and writes 2800; the measurement in fig. 3.3 is incorrect.

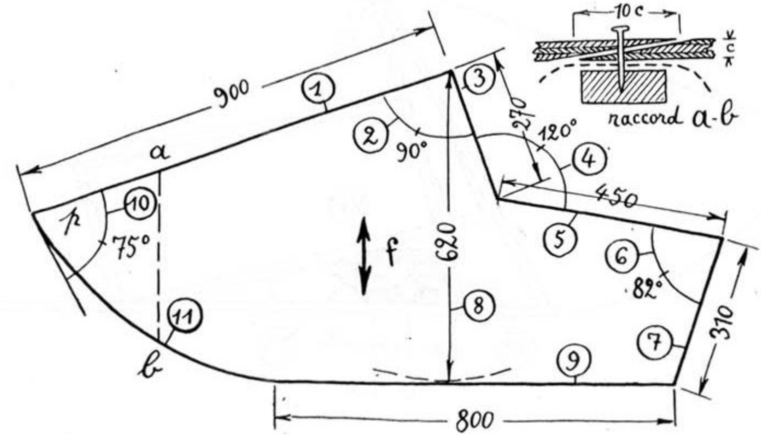


Figure 3.2: Outline of fuselage side

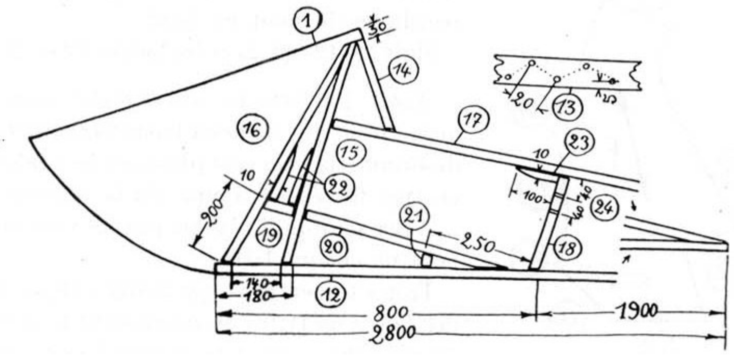


Figure 3.3: Layout of longerons and members, fuselage side

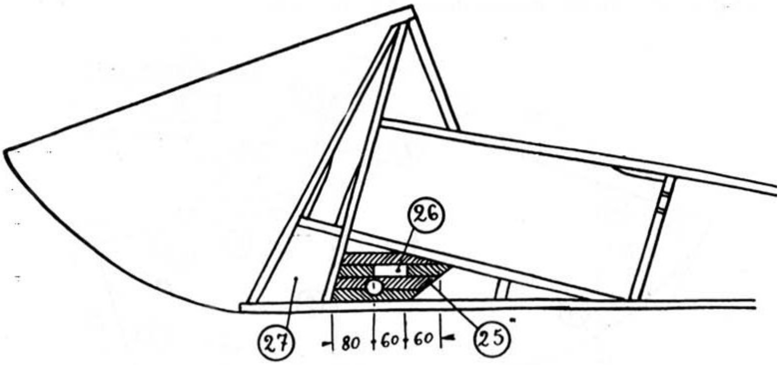


Figure 3.4: Openings at bottom of cockpit

To glue, spread the glue on the first 800mm of the longeron, so there are no bare spots. A nail at each end will steady it while you nail in a zigzag pattern every 20mm or so, as seen at ⑬ in fig. 3.3. After nailing, the glue will be squeezed out along the entire joint. Plane it away when dry.

Continue fastening 20 × 20 members ⑭, ⑮, and ⑯, ending 30mm shy of edge ①.

Then put in place longeron ⑰ which runs from member ⑮ to end in a bevel against longeron ⑫, which is straight from end to end.

Then ⑱, ⑲, ⑳, ㉑, and blocks ㉒ and ㉓.

N.B. Member ⑱, *before it can be fitted*, must be drilled with two holes ㉔ 40mm apart. These are for the 5mm threaded rods holding the safety belt.

Be careful to leave no gaps at the ends of the various members.

Make the blocking ㉕ in fig. 3.4 with pieces of slats, leaving

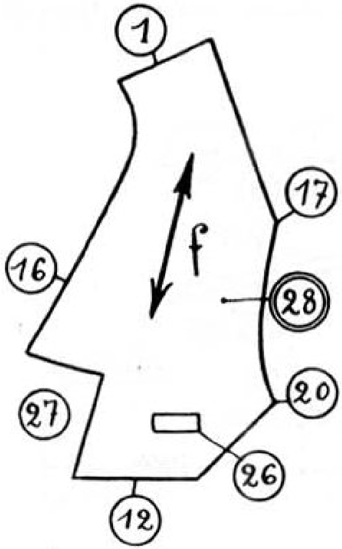


Figure 3.5: Plate inside front of cockpit

the gap 26 which measures 20×60. With the tip of a knife, remove the plywood over this void; the pulley of the rudder cable will be placed there later. Also remove the plywood covering the quadrilateral ㉗, through which the axle will pass.

Cover that assembly with plate ㉘, fig. 3.5, made of 3mm plywood, of which side ① is 150mm long.

Prepare the second side, *exactly like* the first, but reversed; *i.e.* with the longerons, members, etc. on what will be its inside.

I must emphasize: wherever wood touches wood, you must glue and nail.

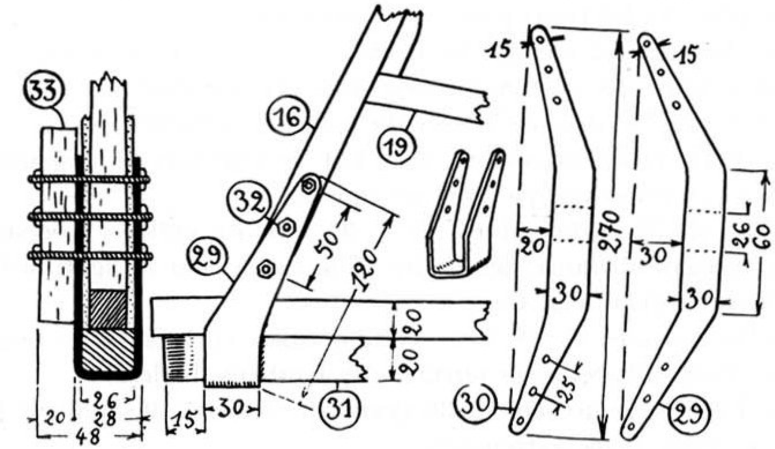


Figure 3.6: Landing gear reinforcement

In a sheet of 1mm soft steel, cut two strips ㉙ and ㉚, which, when bent, will be held in place by gluing under the lower ends of members 15 and 16 a pad, ㉛ *(fig. 3.6)* of hardwood — walnut, oak, beech, etc. — $20 \times 26 \times 230$. Only drill one side of these fittings for now. The other side will be drilled later when it is bound or clamped in place.

The bolts ㉜ of 5×60 threaded rod will further secure the flanges ㉝ of 20x20, which will be inside the fuselage.

Figure 3.7 gives the overall appearance of the finished assembly.

The pad and the flanges reinforce the longeron ⑫ when the axle strikes it in rough usage.

A hardwood block ㉞ $10 \times 26 \times 50$ is glued and screwed onto the pad at equal distance from the flanges. It will prevent the bungee cord that secures the axle from slipping.

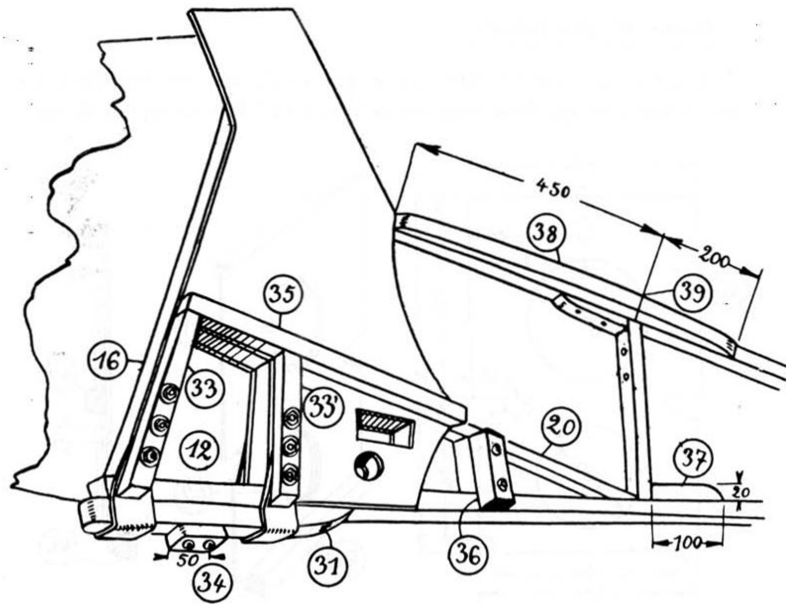


Figure 3.7: The completed assembly around the axle

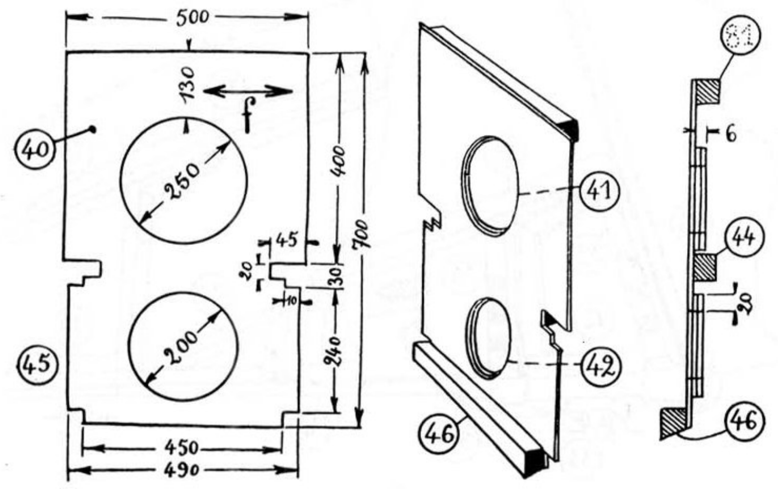


Figure 3.8: Pilot's seat back

Glue on the wedges 35, 36, and 37 — the latter made of hardwood — to which the wing brace fittings will later be bolted.

The reinforcing member 38 is 20×20 at point 39 and thins gradually toward its ends.

3.1.2 Joining the sides

The two sides will be joined by the pilot's seat back 40, of 3mm plywood as in fig. 3.8. Holes 41 and 42 are reinforced with plywood rings, and provide access to the luggage compartments.

The holes and rings can easily be cut with a carpenter's compass with one branch sharpened to a cutting blade.

On the panel 40 place only the bar 44, $20 \times 20 \times 410$, and nail

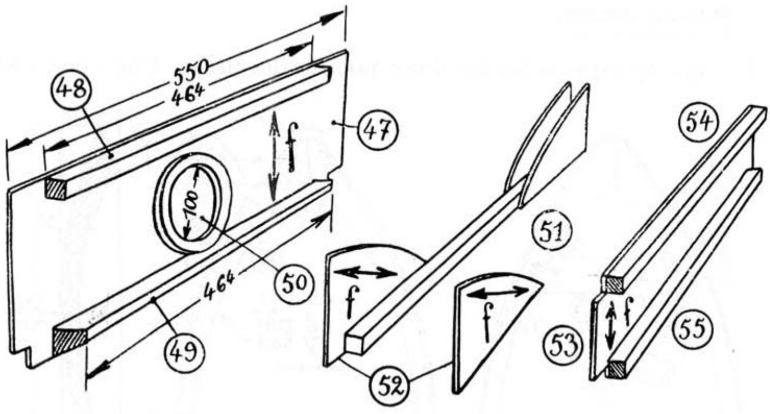


Figure 3.9: Front panel joining sides

the sides (45) in front of member (18). Then add cross-member (46), beveled to be flush with the underside of longeron (12).

The front flanges (33) are now joined by the panel (47) *(fig. 3.9)*, cut so that its cross member (48) fits on the shim (35), and its crosspiece (49) at the bottom of the tabs (33) so that cross members and flanges are flush with the longerons (12). The height of the panel (47) will be determined in place. Do not forget that the hole (50) is reinforced with a ring. File away what could interfere with the flanges (29).

The rear flanges (33) are joined at their lower part by a member (51) and double gussets (52).

The same goes for the flanges (36), joined by sheet (53) with members (54) and (55).

The members (46), (20), (35), (48) and (54) are all on the same plane, and support the seat-bottom (56), which is seen from below in fig. 3.10. Determine its form in place with cardboard, so as not to waste plywood unnecessarily. This panel is only secured

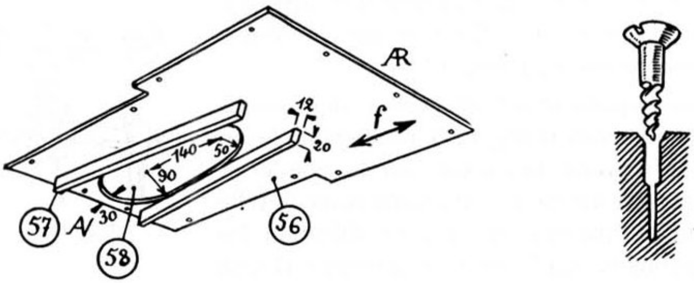


Figure 3.10: Seat bottom from below

by 12 × 15mm round-headed wood screws. It is doubled, to a thickness of 6 mm and glued under weights. Nailing would be useless.

Two members 57 stiffen the seat bottom between the cross-members 48 and 54, and the edges of the central hole 58 through which the control stick will pass. At each end of the members, put in place a wood screw with a washer.

Screws: Before inserting a wood screw, drill a pilot hole two-thirds the diameter of the solid metal part of the screw. Rub the threads with beeswax.

3.1.3 Front point

The two ends of the flanks are brought together by a "lyre" 50 cut with a saw from a 20mm hardwood plank *(fig. 3.11)*.

Because of its incline relative to the fuselage, it will be necessary to bevel its outside faces 60, to decrease the upper face

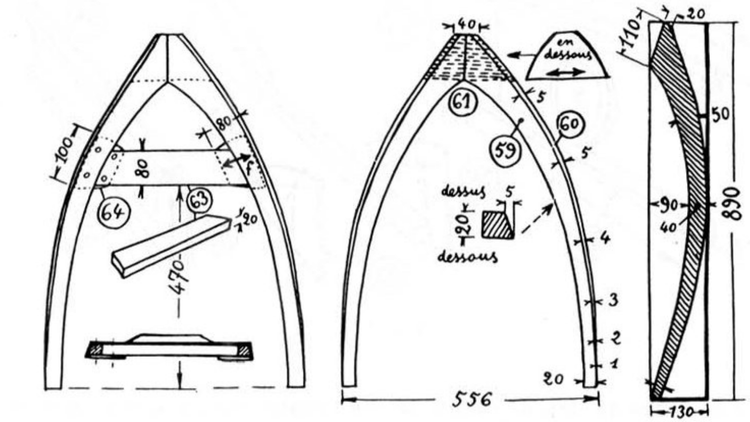


Figure 3.11: The "lyre"

according to the progressive dimensions indicated: 0, 1, 3, 5, 5, 5. The branches will be separated by 556mm by adjustment of the joint ⑥①, which is reinforced below by the triangle of plywood ⑥②. It is also stabilized in the middle by a board ⑥③ of 20mm hardwood closely fitted and strengthened below by 6mm gussets ⑥④. All this is to be well glued.. This board will be reinforced by bolted fittings, and will support the engine.

Bevels, adjustments, and fitting should be begun with the plane and finished with a large half-round bastard file — for metal, not wood. It should be bought and kept like new, used only for wood. It is preferable to a wood rasp, which tears out the grain, and after the glue dries, it will munch away at the wood as well as the wood rasp, even if there are nails — which would ruin the rasp or the plane immediately.

Put the two branches of the lyre together between the plywood sides ① and the plywood panels ㉘ *(fig. 3.12)*. Nail so that the two sides ⑥⑤ meet slightly past point ⑥⑥. Nail the

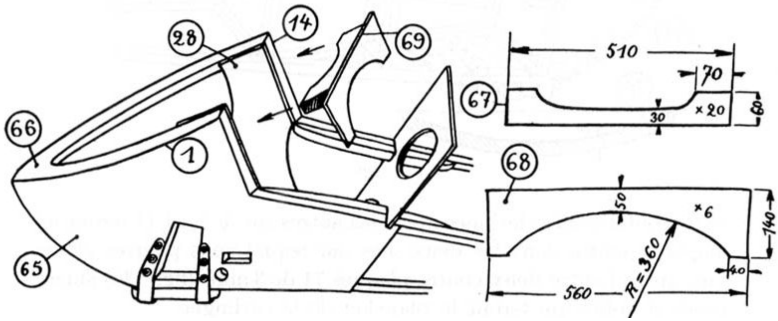


Figure 3.12: Fastening the “lyre” in place

plywood all along the branches, about every centimeter.

Cut off the excess of the branches of the lyre and plane away the side material (1) that extends above the lyre; for that purpose, the sides were drawn out in Figure 3.4 with 30 mm instead of 20 mm.

From a 20mm hardwood board, cut out (67) and nail under the panel (68), 6mm thick, as seen at (69). This will connect the two branches of the lyre and the rim of the cockpit side (14).

3.1.4 Planking

Turn your shipping crate upside down.

Cut out a strip (70) *(fig. 3.13)*, 25mm wide and fitted to the edge (11). Copy it 14 times in 3mm plywood. Seven thicknesses glued one after another inside each side (11) form a flange curved in both directions, on which you can nail one after the other two 3mm plywood pieces (71) *(fig. 3.14)*, layered and glued, which will serve as the cabin floor.

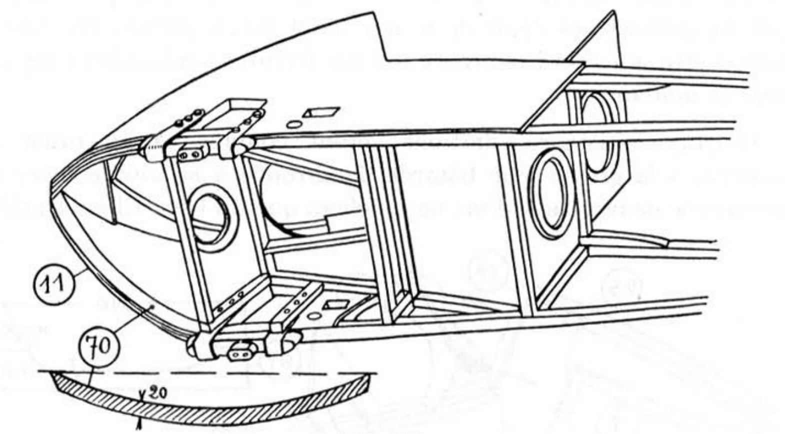


Figure 3.13: Flanges to support cabin floor

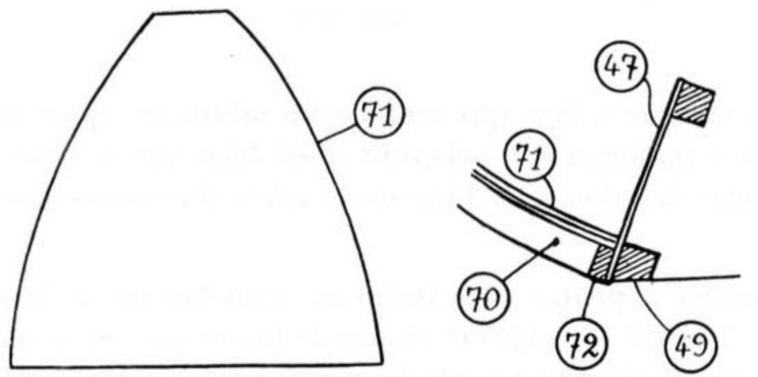


Figure 3.14: Fitting the cabin floor

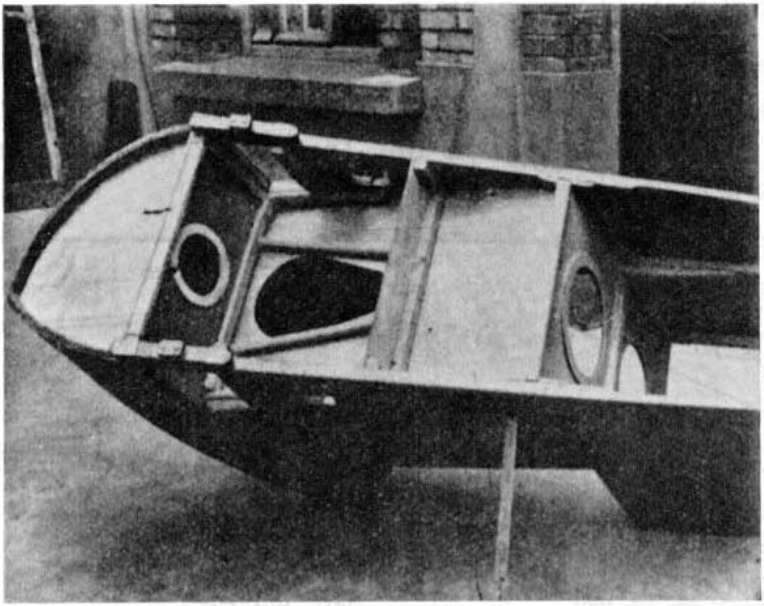


Figure 3.15: The underside of a fuselage before applying the bottom skin in front

The floor is supported by a cross-member ⑫, $10 \times 20 \times 504$, fastened in front of panel ㊼.

With the file, align the lower faces of the flanges ⑰, so a 3mm plywood piece like a curved triangle will have good contact everywhere from the point to the cross-member ⑫. This forms part of the bottom skin of the fuselage.

Now cover the lyre back to panel ㊳ with 3mm plywood.

I am sure you have, by this point, sat in *your cabin* already. Am I right?

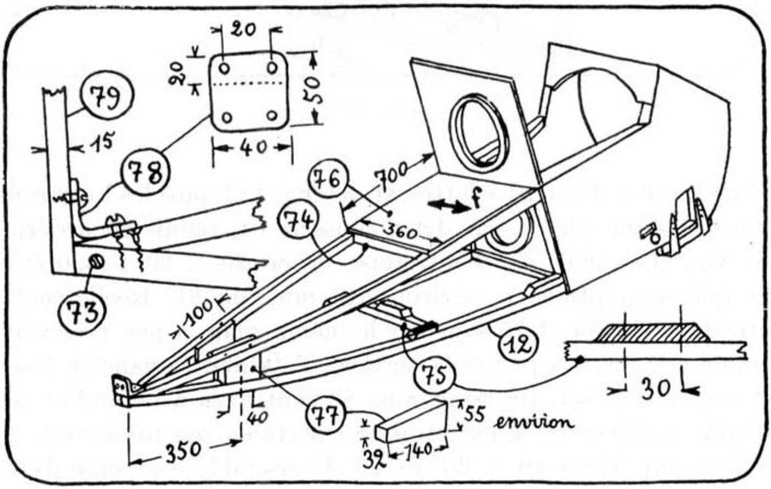


Figure 3.16: Rear point

3.1.5 Rear point

Join longerons 12 and 17 in a point *(fig. 3.16)* with a wood screw 73 4×40 with a countersunk head, making sure to insert members 74 and 75 700mm from the seat back. Put in place the luggage-box floor 76 of 3mm stock, and two hardwood wedges 77 fastened with 2 4×40 round-headed screws spaced 40mm apart, reinforced internally with pieces of 3mm plywood with the grain vertical.

Cut out two fittings 78 in 1mm steel that will be folded into angles. One will be used to attach the hardwood tailpost 79, $15 \times 40 \times 450$, to the rear point, using 4×15 round-headed screws. (This is a provisional attachment pending completion of the final sides.)

Put in place the vertical and horizontal members 81, 82, fig. 3.17, followed by the longerons 83 fixed to 81 on the front by two gussets 84. The longerons are joined at the rear by a screw, and held apart by the spacer 85 (nailed with gussets) placed about 640mm back from 81. The members 85, 74, and 75 are in the same plane, which, like the tailpost, is almost vertical when the fuselage is placed on the ground. The longerons 83 are affixed to the tailpost by the second angled fitting 78.

The spacer 85 has suspended in its middle a piece of hardwood 87, $20 \times 20 \times 100$. The assembly should have two 6mm holes drilled through it, 60mm apart. Similarly, spacer 75 bears a part 89 with 2 6mm holes drilled 30mm[2] apart.

While doing all this, make sure that the tailpost is aligned to the cabin. Plane it down so that it follows the lines of the fuselage.

[2] The text says 60mm, the diagram shows 30mm in two places; the text is probably in error.

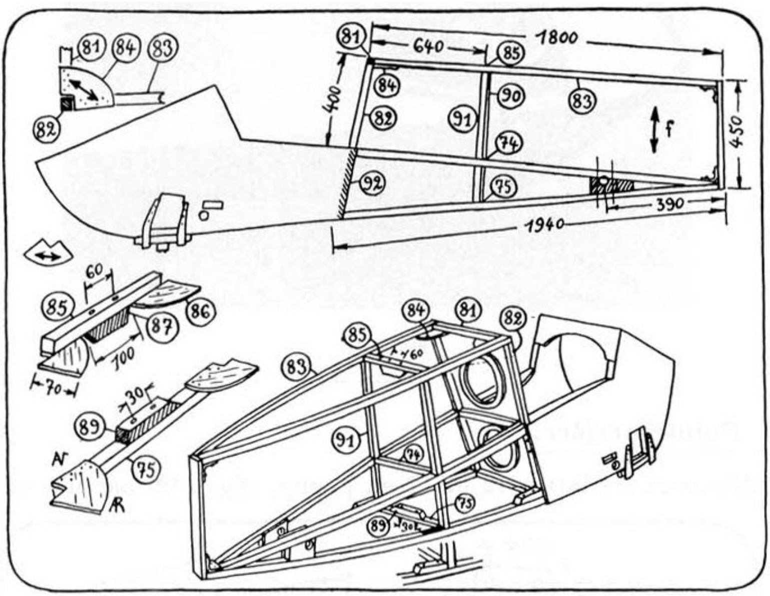


Figure 3.17: Fuselage superstructure

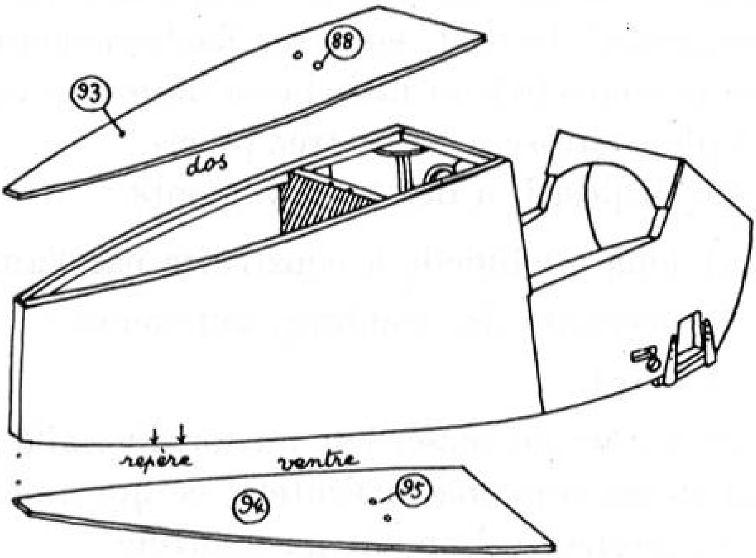


Figure 3.18: Fitting the rear skins

Put in place the bulkhead (90) on members (91) by fastening it behind (74), (75), and (85).

Bevel the plywood sides with a file at (92) so that you can glue to them the rear sides, which will also be beveled, without creating a bulge. (That is, prepare a scarf joint.)

With the help of a few nails, apply a 3mm sheet of plywood to each side. Trace the required shape. Cut it out and nail with plenty of glue. When nailing the second panel, make sure the tailpost is still straight. After it dries, clean up the edges with a plane or file. At this point you have what is seen in fig. 3.18.

You can close the box with the lid (93), drilled with a 7mm hole (88). Remove the screws from the rear blocks (77) and precisely mark their position on the sides. Then install the bottom 94 of the box, drilled with holes 95, up against the seat.

Prepare the 3mm plate which will form the bottom between cross-members 46 and 49, but put it in place later.

The fuselage is complete. You have built it in 4 days. It weighs but 18 kilograms. By skinning the back and bottoms with thinner plywood, by shaving some members in excessively strong spots, the weight might have been reduced by a kilogram. Reinforcements and shims would have had to be added, and even so, the plywood would soon warp. A clumsy move, a pebble, a branch of a tree, a wire dragging on the ground, would have wrecked it. Our machine is not a window display; it is to be used.

3.2 Landing Gear

3.2.1 Tailskid

In the first edition, I had shown the rudder and twin biconvex wheel as a solid assembly whose bearing axis was the rudder control, all as a block, elastically attached to the fuselage. The pilot could maintain control both at flight speeds and taxiing at low speed. It was very precise.

This device had its disadvantages, however:

(a) It was difficult and time-consuming for amateur construction

(b) It required welding

(c) It is heavy

(d) It carried the risk of breaking on rocky ground, or if the welds were poor, which could cause a catastrophe if the rudder became uncontrollable

(e) It was too easy to steer on the ground for learning

(f) It dragged badly on landing

In this edition, I abandon that system, and substitute the old uncoupled rudder control and the well-known tail skid used on the HM.8, which we amateurs have used and perfected.

The trailing joint of the longerons (83) is clamped inside a fitting (96) in 2mm steel by three 5mm threaded rods (97) *(fig 3.19)*. An exactly similar fitting is held to the trailing joint of longerons (12) and (17). Their outer lugs connect them to the lugs of the rudder fittings (111) and (112), by hinge pins (98) and cotter pins (99).

Fitting (112) carries the horns (102), made of 7mm drawn rod, flattened at the ends and pierced to receive a little steel axle, which holds fittings (100) and (127) together. These horns are wired to the trailing edge (113) of the rudder — at the location of a rib gusset — with a 2.4mm cable (114).

The pair of cables that connect the horns to the control stick are adjusted by turnbuckles (122).

The tailskid is formed like a triangle of 10mm drawn soft steel wire (104) with the ends bent in and aligned on the same axis to go into the 2mm sheet steel fittings (107).

The fittings (107) will be fastened with bolts (115) of 6mm threaded rod, taking care to align the heavy wire loop (106) with the center line of the fuselage.

An opening (108) cut in the sides provides access to the nuts fastening the bolts (115), which clamp a plate of 2mm

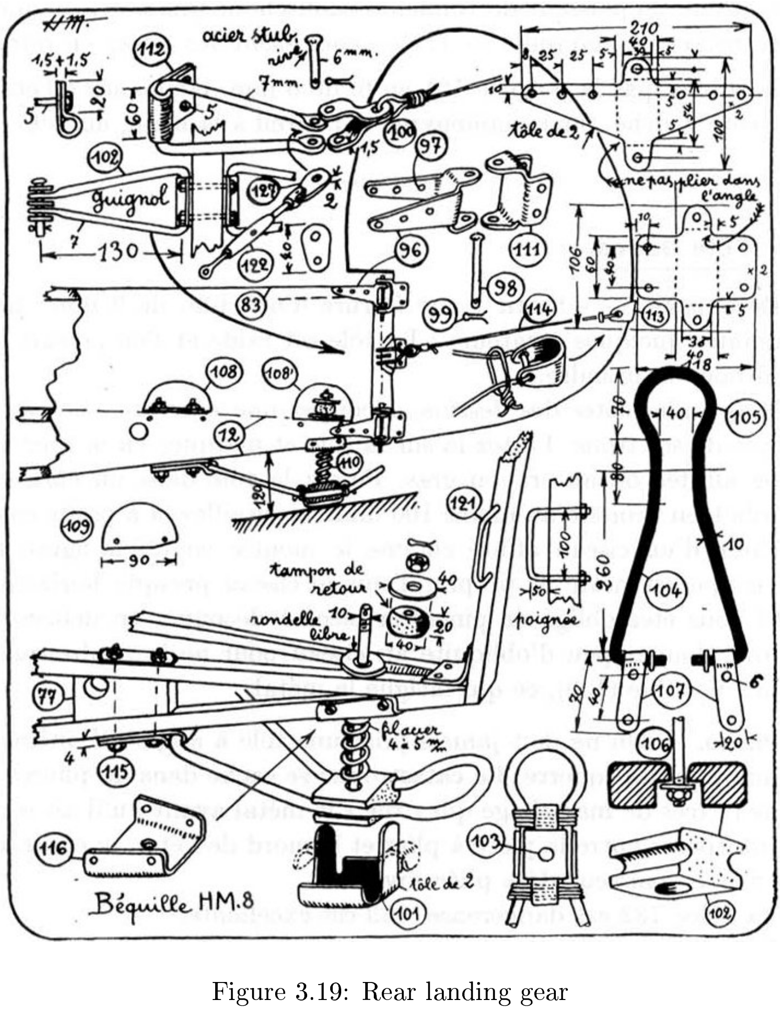


Figure 3.19: Rear landing gear

sheet on the piece of hardwood 77. Small covers (109) made of 0.6mm aluminum sheet screw over the opening.

The shoe (101) of 2mm sheet steel is attached to the loop (105) by a hardwood wedge (102), pierced with a hole (103), which receives a 10mm rod (106) with a nut, holding a spring (110) which yields at 40kg (12 turns of 35mm steel wire, like 6mm motorcycle seat springs); then a sheet-metal bracket (116),secured under the fuselage by 4 good wood screws; a washer 2cm thick; a rubber donut 40mm in diameter; a nut; and a pin (117). All this forms the shock-absorber.

Do not forget the handle (121) of 6mm wire, bolted to the left side, which eases ground-handling.

3.2.2 Interlude: Mild steel sheet

Cutting — Cutting a fitting from a sheet of 2mm steel can intimidate some amateurs. The sheet is stiff, and one doesn't know where to start.

Cut out a cardboard fitting made to the dimensions in the drawing, and pierce it with holes. Fasten it to the steel sheet and mark the outline with sharp chalk or a grease crayon. Clamp the sheet in a vise with straight edges of at least 100mm, and cut it with a sharpened chisel as shown at (129) in figure 3.20. This will make a clean, accurate cut. Hold the chisel almost horizontal.

Bending — One should never bend steel sheet at a sharp angle, even the smallest piece. Disaster hides in these bends, because the excessive hammering “kills” the metal before it has been used. To avoid it, place between the

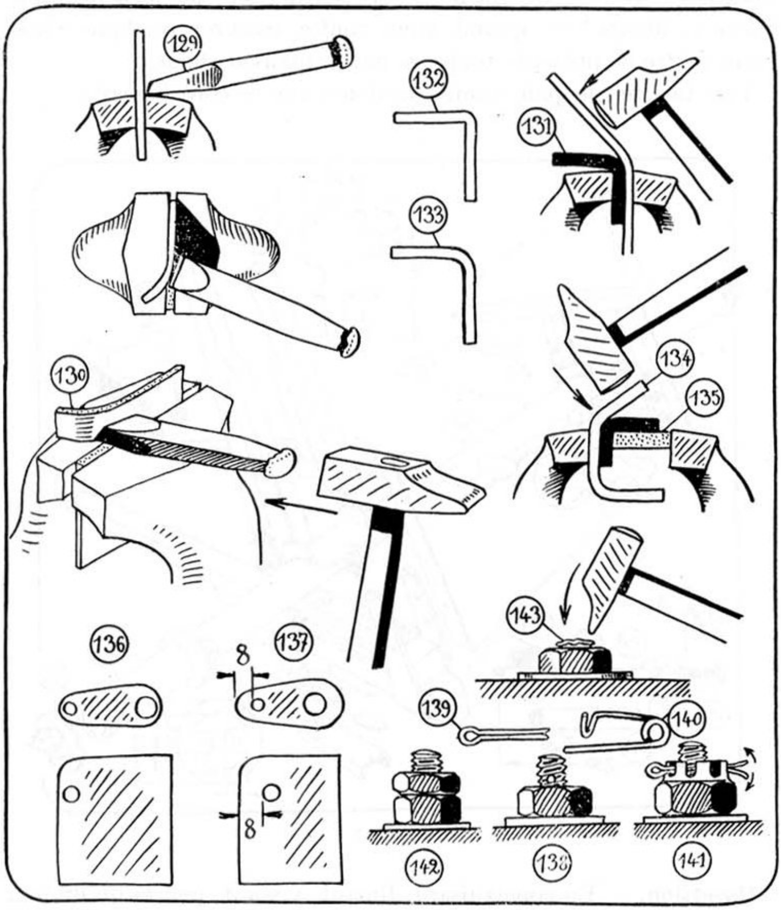


Figure 3.20: Fashioning sheet steel fittings

piece to be bent and the jaw of the vise a piece of the same thickness that has already been bent correctly. (132) is a dangerous piece, but (133) is excellent.

To bend in a "U" (134), put in a piece as a spacer (135), *e.g.* an old, worn-out file.

Drilling — Drill away from the edges. When my drawings do not specify the dimensions — I didn't draw them for fools! — leave at least 8mm between the hole and the edge of the fitting, and if possible 10mm. Leave an equal amount all around the hole. (136) is very bad, but (137) is good.

Fastening — On an airplane, all bolts must be secured. When the part is frequently disassembled, the nut (138) is secured with a pin (139) or (140). In more precise assemblies, use castle nuts (141) or lock nuts (142)

When the bolt is not intended for disassembly, a few hammer strokes will roughen the threads (143) of the bolt that protrude about 2mm beyond the nut. Before disassembly, a light filing removes the roughness and allows the nut to be removed.

Not a nut, not an axle, not a turnbuckle may be forgotten. If you neglect to tighten a dozen nuts on purpose, none will come off. But if you forget one, and it is important, that is the one that will desert you: you will drop parts all over the landscape! Nature abhors a vacuum and despises order, and will have its revenge... For the same reason, if you drop a nut, it immediately becomes invisible — where is it? — Cuddled up behind a table leg. Never anywhere visible! When you want to measure anything, your ruler is always at the far end. Bread always falls butter-side down!

Obsession — In building, filing, and fastening, remember that one day soon the piece you are working on will be what holds you suspended in the void, a thousand meters above the ground…

3.2.3 Front landing gear

The axle is a 36×40 tube (144) *(fig. 3.21)* 1200mm long, filled with another reinforcing tube, 31×35 800mm long. This is 4mm thick in total, and weighs 4kg 300g. It is heavy — very heavy. But it's solid! The axle won't bend. You won't have to worry about beating your landing gear into a curve rolling over the clods. Do not repeat the author's mistakes — *only one tube is not enough*.

1mm play between the tubes allows you to assemble them; if you made them fit tightly, you could not fit them together. I do not recommend a wooden sheath, which, while lighter, prevents neither bending nor breakage. Its elasticity allows the metal to fatigue, and your axle will eventually break from a light bump.

A collar (145) of 2mm sheet is tightened onto the tube by its 6mm bolt (146). This collar prevents the tube from slipping through the bungee cord, just as the block (34) holds it under the wooden pad under the cabin.

Neither drill any holes nor do any welding on the axle just now.

An 8mm rod (147) crosses the axle in the middle. On it are, in order, a tube (148) of rolled 1mm sheet, a plate washer (150), rubber washers (149), another washer (150), and finally a nut (151). This prevents the axle turning by bearing on the front floor through hole (50)

The axle rests on a 12mm-thick rubber pad (152) cut from the tread of a used car tire. This pad is placed on a folded

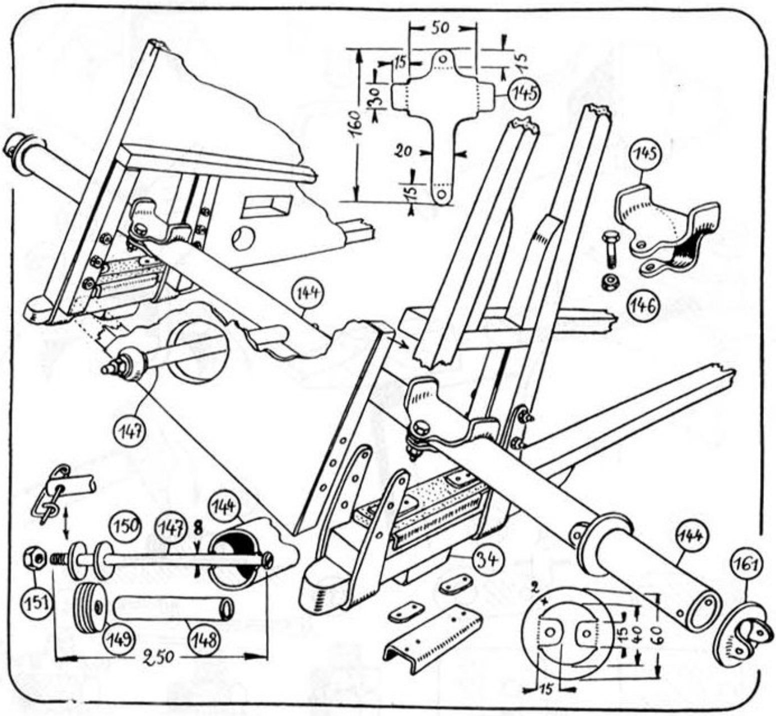


Figure 3.21: The axle and its placement

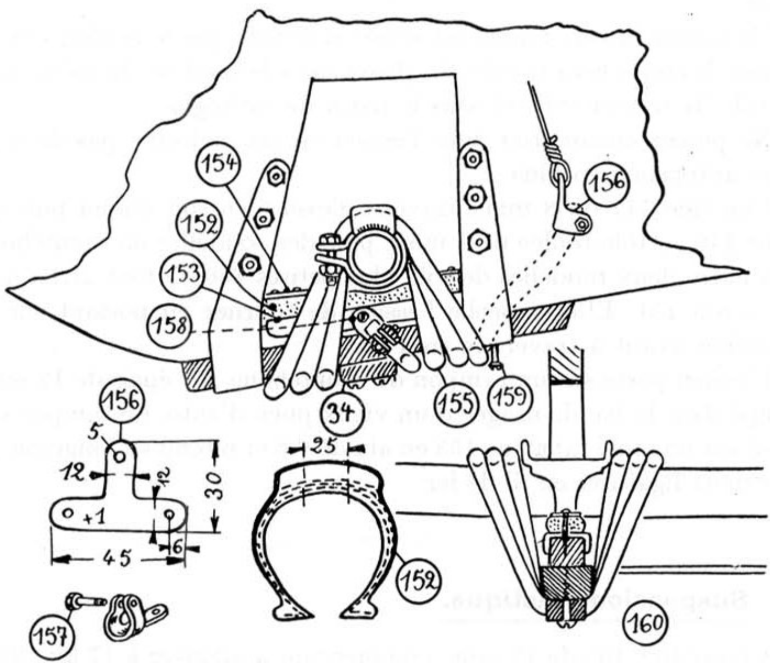


Figure 3.22: Rubber pads and bungee cord

sheet of 0.6mm aluminum (153) and held to the longeron (12) by two steel wire ligatures *(fig. 3.22)*.

3.2.4 Bungee suspension

A 12mm bungee cord (155) 1m 90cm long, which starts to stretch at 17kg, is clamped at each end in a fitting (156) of 1mm sheet metal held by a 4mm bolt (157). *Fastening*: One end of the bungee cord is fixed under the axle by a 4×20 screw (158). The bungee goes behind the block (34), and then six times around the axle and under the pad as shown in the figure. It is stretched so that it extends a little. Leave no slack. The other end fitting is attached to a 2mm wire, which is fastened somewhere under the seat bottom. A screw, (159), prevents the rearmost strand from sliding. Be certain that the axle, in the play allowed to it, does not rub on an immobile strand of bungee.

Before cutting the bungee cord to length, tie it with string two times; then cut it with a sharp knife between the ties.

From the front, the suspension appears as at (160), where we see the axle, its collar, the rubber pad, the folded sheet, the longeron, its reinforcement pad, and its lower block with three strands of bungee on either side, which makes 12 total strands of suspension on either side of the cabin. The machine can roll on a single wheel without stretching the bungee cord shock absorber.

The wheels are held at the end of the axle by the washer/collars (161), held by a horizontal 5mm bolt, cut from 2mm sheet according to (162)[3]. 15mm long 40×44 tube ends would

[3] I am unable to find this reference number on any drawing, but (161) is in Fig. 3.21, and includes layout details for the washer collar in question.

also serve. Insert a washer between the wheel and the sleeve.

This landing gear is not as smooth on rough ground as a triangular frame with coil springs, but it is simple, rustic, easy, light — and aerodynamically sound.

Work: 1 day; weight with wheels: 12kg.

3.2.5 Wheels

I strongly recommend 450×10 tires, not too inflated, which absorb most of the normal shocks due to rough ground. The big shocks are handled by the bungee cord. Inflate the tires so they barely hold their round shape.

Grease the axle often. Amateurs have often had them seize due to negligence.

These wheels are small; the belly of the fuselage is only 14cm from the ground. It seems weak. Practically, I have never had trouble. This should not, however, prevent you from carefully surveying the starting ground and beating the most prominent molehills down with a shovel.

I suggest that manufacturers give thought to aircraft of about 200kg gross weight, and make tires weighing 1kg with hubs the same weight. It must be possible. They'd sell like hotcakes!

We would also need a spherical tailwheel 140mm in diameter.

3.2.6 Control stick

A tube 163 *(fig. 3.23)* passes straight through the fuselage below the rectangular hole 26 *(fig. 3.4)*. You will have to use a brace and bit to drill a hole (164) as seen at (165), and use a rasp to fit it to the diameter of the tube, *i.e.* 24mm.

The middle of the tube (163) is held between two wedges (166), surrounded by two cheeks (167) of 2mm steel, all held by four 5mm bolts. The control stick (170) pivots between these two cheeks on a 6mm bolt (168) and two 1mm washers (169), reinforced at this point with a sleeve. Riveted at the top of the stick is a hook (171) of 2mm sheet metal, which allows a secure grip.

The tube (163) extends beyond the fuselage sides by about 50mm. Two collars (172) prevent it from slipping laterally, *without play* if at all possible. There must be washers between the fuselage and the sleeves.

These sleeves also bear the horns (173), and are fastened to tube (163) by a 6mm bolt (174), so that the horn forms an angle of about 90° with the handle.

The horns, one on each side, for control of the wings, will be bound to them by a rigid pushrod.

The rudder control can be hooked up now. Two 2.4mm steel cables, 5m long, will be passed through the 6mm hole (175) in the handle, and fixed in the middle by a 4mm bolt (176). Each double strand will cross the other in the 5mm hole (177), and then again in notch (178). The handle will have been filled with hardwood rubbed with paraffin, flush with the base of the handle. The wood and metal notch will be filed in a circle according to 179. A 4mm rivet (180), flush with the handle, prevents the cables from escaping the notch. A drop of oil will prevent cable wear, but you must keep an eye on it and replace the cables according to need.

Each double strand 2m 50cm long, runs over the pulley

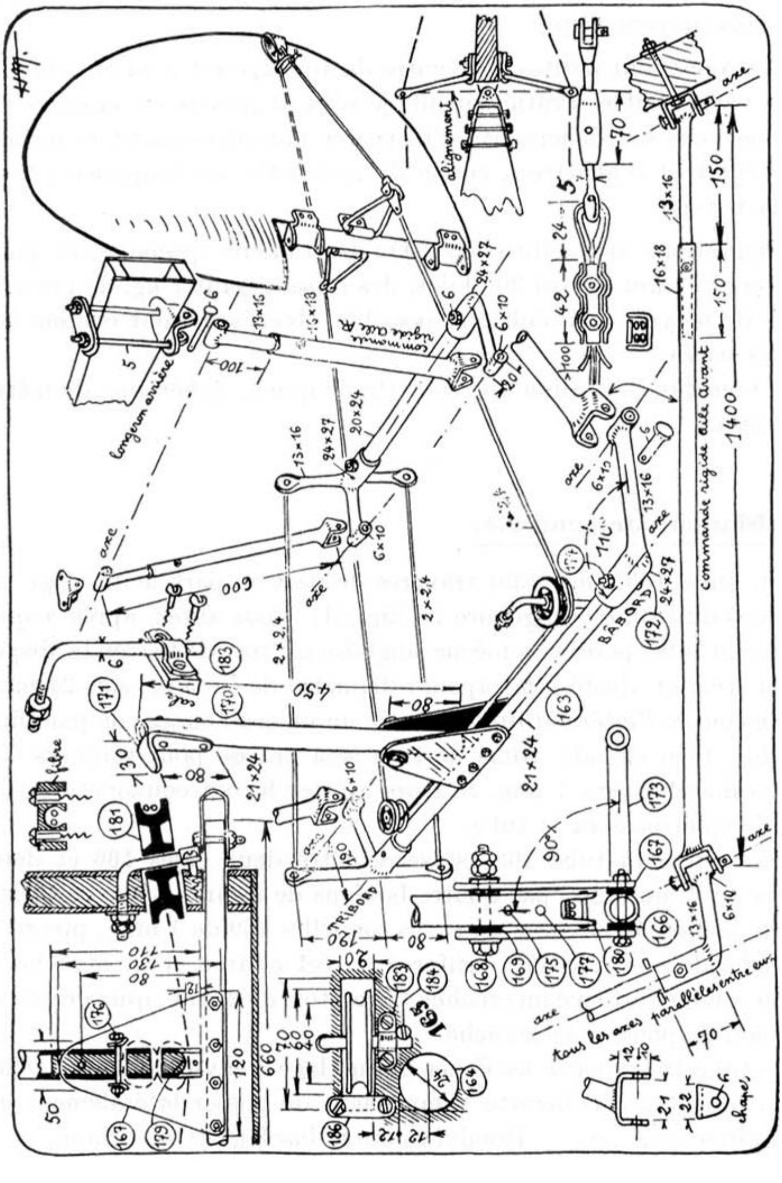


Figure 3.23: Layout of control system

181, which is of cast iron with a very wide groove, no less than 40mm, and can be bought at any hardware sellers' — rotating on the 6mm shaft 182. A fuselage nut inside the fuselage on one end, a bracket 183 on the other, and a 5×25 screw 184 below the bracket secure this shaft at a slight tilt (with a wedge under the end of the shaft) to align the cable's path with the base of the handle.

Finally, the double strand will join the turnbuckle 122 *(fig. 3.19)* where it is attached by a cable clamp 123 designed for 4.5mm cable. Tie each loose end and join them both to the cable. Leave 50—100mm excess.

A small 2mm sheet 185 flush with the pulley and applied by two screws will prevent the cable from escaping and getting caught if it were to become loose. Wise precaution — you never know! The tendency of a cable to stick is powerful, and if there are only two pulleys in the Pou-du-Ciel, it's two pulleys too many! A million bucks to the one who can get rid of these two pulleys!

The front-wing control horn 420 is connected to the rear-wing horn 421 by two 2.4mm cables 422, each doubled, like those of the rudder[4].

This rear horn has a projection 423 which moves a pushrod 424 carrying a projection 425. The shaft turns in a waxed hole drilled in the filler piece, 77.

The two projections 423—425 control the rear wing by two arms 426 pivoted on clevises 427 bolted to the small spar of the rear wing.

Time: 2 days. Weight: 2.3kg.

[4]The reference numbers 420—427 in this paragraph and the following ones are not to be found in the figures. Their referents are mostly obvious, however.

3.2.7 Cabane struts

The cabane is the steel-tube pylon which supports the wing and holds it in position with regard to the fuselage before it is secured by the bracing wires.

It is made *(fig. 3.24)* of two 17×20 tubes (187) welded onto two 2mm cheeks (188), which are separated by a block of hardwood (189) and fastened by two 6mm bolts. If welding is not available, bolt as at (190). This is the top of the cabane.

The bottom of the cabane, slightly curved while heated red-hot and filled with hardwood, are held in U-shaped brackets (191) of 2mm steel by a 6mm bolt. These are linked to another bent fitting (192) by two 6mm bolts, enclosing the cross-member (67) and giving the structure great strength, fitting (192) being bolted on its other side to the three members (14), (15), and (16) of the undercarriage.

It would be better for the lower ends of the cabane struts end with a welded transverse tube (193).

The top of the cabane is fixed in place by a tube (194) about 300mm long — to be determined at the time of adjustment of the wing — and which is fastened, top and bottom, on 30mm tubes (195) of rolled 1.5mm sheet. The tube-axis of the foot is clamped between two brackets which will be bolted to the engine when it is installed.

The small tube (195) at the cabane top forms the axis around which the wing rotates. To achieve this, a 200mm bolt (197) of threaded 10mm rod runs through the wing vertically and retains the U-fitting (198), which is welded to a tube of rolled 2mm sheet. Pivoting is provided by these two tubes rotating one over the other — one attached to the cabane, the other secured to the wing. If weld-

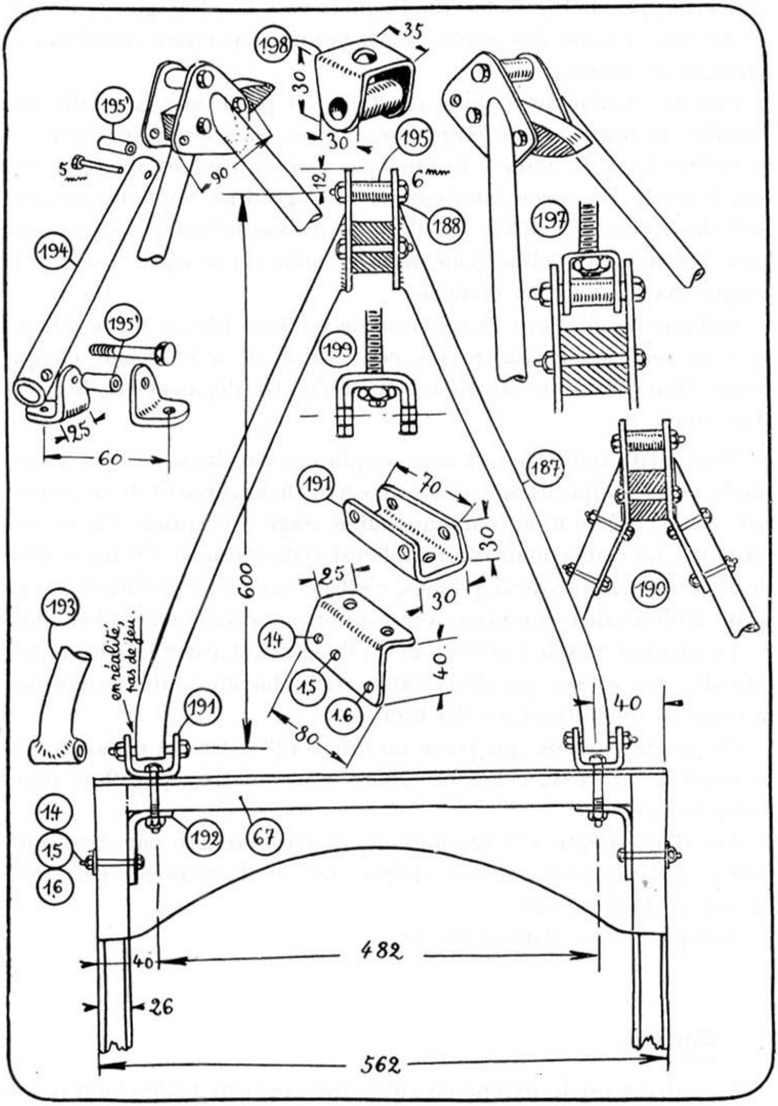


Figure 3.24: Layout of cabane struts

ing is unavailable, a fitting without the tube but of doubled sheet as shown at (199) will suffice. Tube (195) must be fastened, and adjusted so the fitting (197) moves freely without lateral play. Precise fitting of the tubes is unnecessary; 1 or 2mm play will not matter as long as they are approximately round. A drop of oil will fix everything. Let the engineers laugh... Why bother if it's not necessary?

Time: 1 day. Weight: 1.5kg.

Chapter 4

Wings! Wings!!

4.1 Wingspan

My intent was to give the amateur a Pou-du-Ciel project that he can build in his apartment. A space 4×3m should have sufficed. The fuselage, the rudder, the rear wing... all possible. But what about with this bothersome front wing?

Four meters wingspan would have been fine.

I tried.

A first, flat-bottomed airfoil carried me to the flats of the Aisne valley poplars. The engine, running full out, quit. I came down in a 60m meadow surrounded by walls, with an apple tree and a horse. I hit a manure pile without much damage. Another more curved profile got me up to 100 meters. It climbed like an old man climbing stairs: very slowly, with much huffing and puffing. It made me want to pedal!

So much for 4 meters. I stretched the wing to 6 meters and the highlands, the towns and the forests dropped away beneath my wheels, the landforms flattening before me. It was too good to abandon. For a span of 6 meters, the amateur will have to make what shift he can.

After a few mishaps, I settled on an autostable airfoil. By ongoing study of the two wings' interactions, I was able to modify the section given in my former book to improve the performance of the Pou-du-Ciel 1936.

4.2 Forward wing

The structure of the wing *(fig. 4.1)* consists of 18 ribs strung on a 6m main spar 200. A smaller 5m spar 201 is threaded with the tail ends of 12 ribs, all the same; the three ribs numbers 7, 8, and 9 on each side are different because of the planform of the wing.

The trailing edge 203, made of three glued strips, and the small spar triangulate the frame that needs no additional stiffening. Thus, inside the wing, except for the nails for the plywood, there are no metal parts: no fittings, no wires, no turnbuckles.

The center of the wing is supported on the cabane by a block 204, while a system of struts fitted to the wing at 205 fix it firmly along a pivot axis 204—205.

The pivoting motion is regulated by the rod which connects the control horn 173 of the control stick to the rear spar, on which this rod is fixed to two shims at 206.

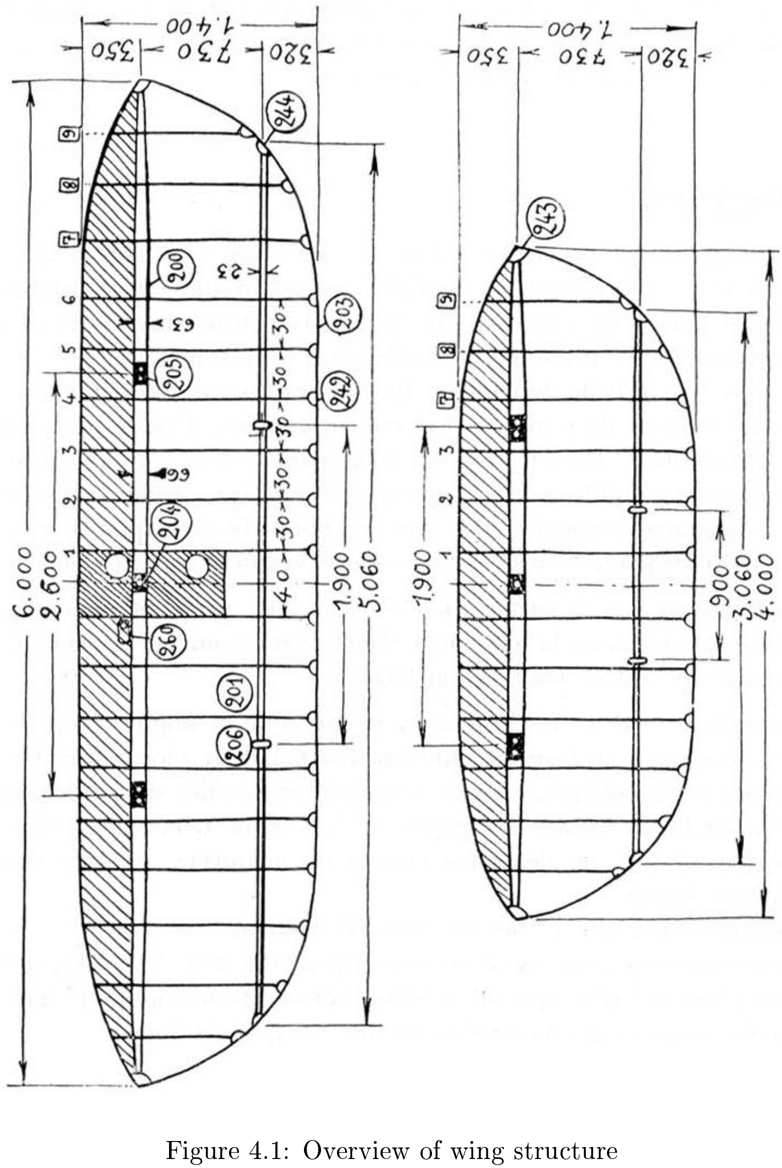


Figure 4.1: Overview of wing structure

4.3 Main spars

The spar *(fig. 4.2)* consists of two 15×60 caps 207, 208, curved to meet at the tips and held in shape by two vertical-grain plywood webs 210. The spar is 150mm deep.

It can be hard to find 6mm lengths of fir free from knots; their length also makes them inconvenient to ship. So let's begin with two lengths of 3m 20cm which can be joined with a scarf joint. Plane the ends of the two 15×60 boards together, as at **A**, to a slope 400mm long, clamping them firmly to the workbench.

Make sure the surface *a b c d* is flat and even. After you plane, use a file or fine rasp to remove the gloss. Form the other ends as at 209.

Join — **B** — the bevels with plenty of glue and align the two lengths of wood well, immobilizing them with two nails in *e* and *f*. Tighten — **C** — the joint, protected with double sheets of newsprint, between two blocks *g* and *h*, in the jaws of a vise, strong carpenter's clamps, or pressed with very heavy weights.

Let dry 12 hours in summer, 24 in winter.

Then prepare for each wing the wedges 204, 205, 212, and 213, which can be in excellent fir or in beech. All holes are 11mm. Also prepare 5 10mm threaded rods 200mm in length.

4.3.1 Assembly

Having removed the two spar caps from their clamps, and cleaned up all four sides, drill an 11mm hole in the

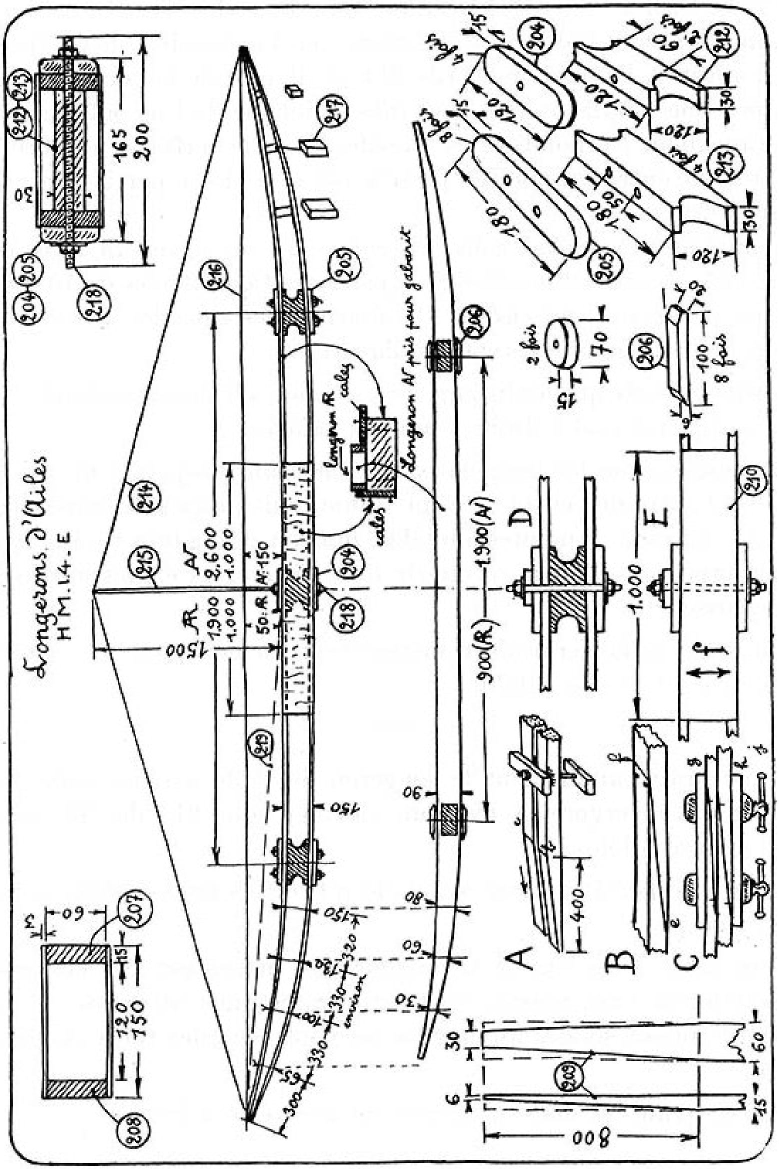


Figure 4.2: The spars

middle, and two holes, 50mm apart at 1.3m to either side of the middle. More precisely, these double holes will, on the upper cap, be 3mm closer to the middle.

Put the two spar caps on two sawhorses and join them with plenty of glue — as seen at **D** — by the block 212, under the also firmly-glued plates 204, and by the 10mm threaded rod 218 and its two nuts with washers. 10mm lock nuts are sufficient — and lighter than normal nuts. Make sure the spar caps are parallel to each other from end to end for now.

Then glue — as seen at **E** — on each side, two strips 210 of 3mm plywood, 150mm wide over *f*, and 1m long (for both wings). Using a rope or a 2mm wire 214 and a 1.5m rod 215 of wood, bamboo, tube, or the like, flex the tips of the spar caps upward so a string 216 stretched between the wingtips passes 150mm above top of the newly-boxed center section.

Insert the blocks 213 with plenty of glue. Tighten them under the plates 205 using their 10mm threaded rods, but *do not glue the plates*.

Little temporary blocks 217 will hold the spar caps spread toward the tips, according to the approximate dimensions shown.

Make sure the bending of the spar caps, verified by string 219, is approximately the same on both sides.

Cover both sides of the spar, using 3mm plywood up to 1.3m either direction from the center, then 1.5mm for the remainder, and nail with fine 8mm nails every 15mm in a zigzag pattern. Use butt joints, or, if you use scarf joints, do not allow extra thickness.

In all, this 6-meter spar used a little over 1 square meter of plywood, and weighs 7 kilograms.

Build the spar of the rear wing the same way, but to a span of 4 meters and with a distance under the string (216) of 100mm. This spar weighs 5 kilograms.

Let dry 12 hours before removing the threaded rods and the plates (205).

You will be amazed at the stiffness of these spars. They give the impression — and an accurate impression it is — of truly solid work worthy of all your confidence.

These two spars can be built in less than two days.

4.4 Rear spars

The small rear spars of each wing consist of two 10×20 spar caps joined by a single web of 1.5mm plywood. They are 90mm tall. They are built by taking the large spars for a template and giving their lower cap the same shape as the lower cap of the large spar. To aid in that, 6x12 strips should be nailed *under* the caps of the latter and beyond it by 6—8mm on the edge. With its blocks properly arranged, the small spar will take on the dimensions given in the figure. Do not forget the side reinforcement plates (206).

4.5 Ribs

The propeller... is the summation of Aviation!

The rib... is the summation of the glider!

You can mess up a lot of things in an airplane: fuselages that are misshapen, heavy, or spindly; crinkled cowlings; twisty tubes... the curvature of the wing, however, must remain unspoiled. Several countries have established laboratories to scientifically study airfoils. They have spent hundreds of millions! The best airfoils that have been discovered look like birds' wings, and the thin section has not yet spoken its last. Henri Mignet also has his aerodynamic laboratory (which cost him 600 francs!), and gave birth to an airfoil his own way, resembling an autostable pre-war section — O Progress! Its sharp leading edge earned him some sarcasm, but that was not its failing. Its flaw was its hollow underbelly, which, in the attempt to provide autostability, killed its lift.

So I sneaked into a hanger with many French, English, and German airplanes, with my ruler in my hand and a pencil behind my ear.

I, tired of jostling my own airfoil back and forth, was in the presence of a simple profile: rounded leading edges, flat bellies, back gently curved, trailing edges raised slightly... I superimposed several profiles and took an average, aiming at lift rather than speed...

My friend Robineau broke his old wing and built a new one with the new airfoil; we have experimented with it for a long while. Here, then, is the new Pou-du-Ciel.

My old airfoil with its pointy beak and wavy tail are now forgotten in the cabinet.

The sacrosanct airfoil is now supported by a plywood sheathing on the rounded leading edge. The amateur will have 6 hours more work, but the difficulty is not great. The little clever ones behind the barriers will not laugh anymore: here we are working by the book, and the bad guys will look a little green at how disgustingly good the performance has become.

We have too much power now! We may soon content ourselves with a motor bike engine... and the dearest of my dreams will soon be realized...

Aviation for the Little Guy!
Mua-ha-ha!!

4.5.1 Ribs

Cover a board 300×1500 with white paper and draw the profile of the rib as follows:

Draw a straight line (220) *(fig. 4.3)* 50mm above the bottom edge.

Draw upon it 15 perpendicular lines (221) spaced 100mm apart and mark them according to the dimensions inscribed: 60 marks the front of the leading edge, while 13 and 135 mark the respective distances from the line (220) of the belly and back of the airfoil. Continue that way to the tail of the rib, whose trailing edge is 40mm above the line. This line (220) forms the *chord* of the wing.

Join the points you have made, and you will have a section view of the shape of the thicknesses of the wing: the airfoil.

Two cap strips (222), (223) in 6×12 are held along the broken line with 2mm nails whose heads you have cut off. The rounded leading edge is cut from a 12mm-thick board.

350mm back from the leading edge, mark a line (224)[1]: it is

[1] Which is not numbered on the diagram but can be identified by its description.

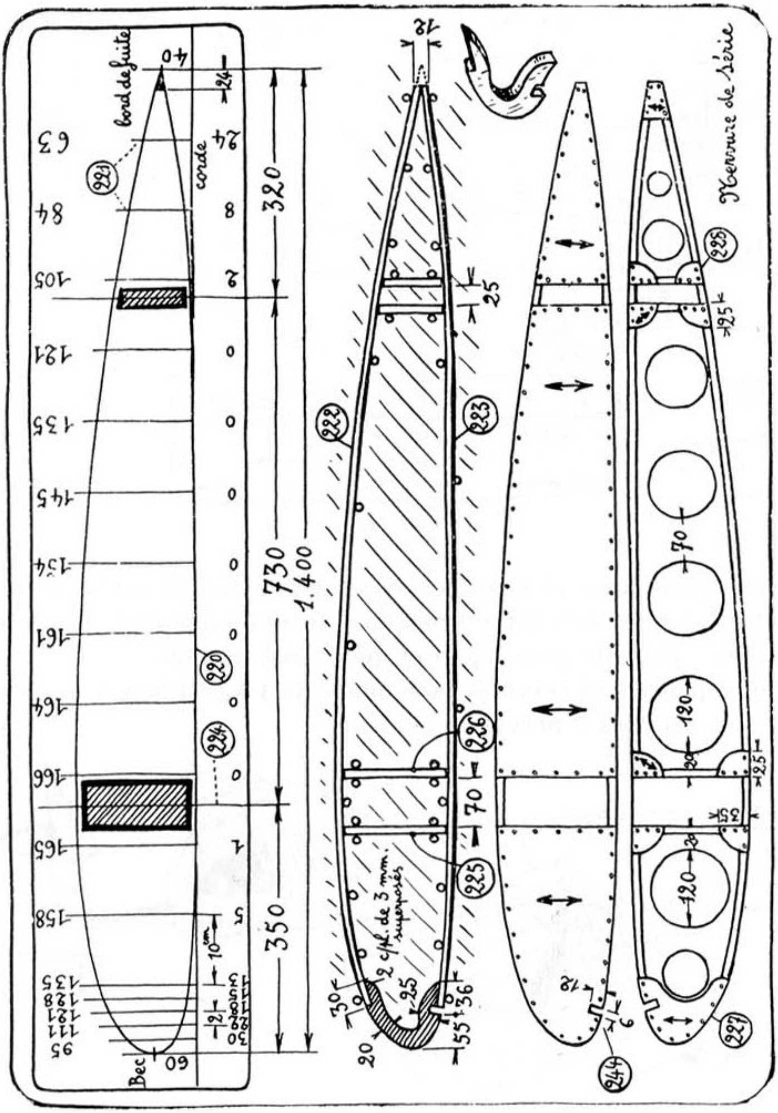


Figure 4.3: The standard rib pattern

the axis of the forward spar bolts. Place a 6×12 member on either side of this line, leaving a 70mm space. This is where the spar slips through the ribs.

Connect the two cap strips (222), (223) with a 1.5mm plywood web, observing the marked direction of the grain. Hold with 8mm brads every 25mm.

Remove the rib from its jig; it has its shape. Nail on the other side the gussets (227) and (228).

Build 19 ribs. The nineteenth, sanded and varnished, hang somewhere prominent in your office, to remind you of these hours of joyful labor later on.

With a hole cutter, lighten the web — it's no trouble. You remove 50 grams per rib, which is nothing. But repeated, it eliminates a kilogram — which is very "Aviation"!

Each rib weighs 230 grams. It takes 10 minutes to nail one up.

The non-standard ribs ⑦, ⑧, and ⑨, of which you make four each, will be drawn and built in the same way; following Figure 4.4.

Webs and cap strips are prepared in 5 hours. The 31 ribs are nailed up in a single afternoon. A few hours of sanding. . . a day and a half, that's all.

The 18 ribs weigh less than 4kg together. 1m^2 of 1.5mm plywood makes seven ribs.

4.5.2 Nailing

You will be able to calmly drive two nails in three seconds using a tilted nailbox, which, shaken by nearby hammering, will orient all the nails with their heads to your right. With a pair of tweezers you will easily grab them and place them one by one under the hammer.

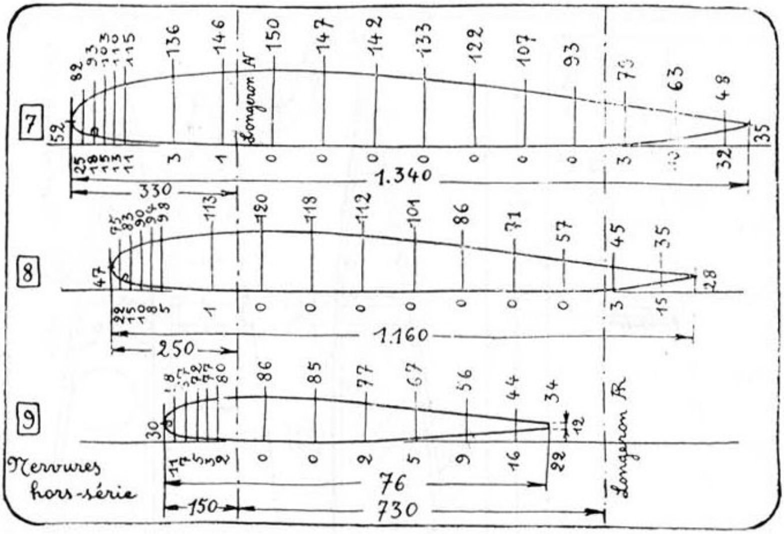


Figure 4.4: Non-standard rib pattern

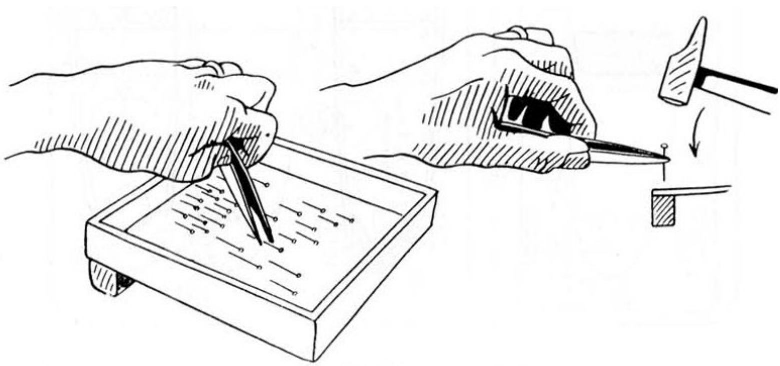


Figure 4.5: Using a tilted nailbox and tweezers

With the first blow, the nail is set. Remove the tweezers. Another blow, and the nail is flush.

You'll be more efficient, and you won't hit your thumb and forefinger *(fig. 4.5)*.

Keep the glue pot well away from the nailbox: Sometimes, in the heat of battle, you dip the glue spreader into it and remove a beautiful glob... unless, distracted, you stick your fingers into the cold, sticky mass...

The Pou-du-Ciel sprouts its two wings in one week.

4.6 Wing assembly

Set the spars across two sawhorses, perfectly parallel and level, with the tips pointing down. Thread the standard ribs *1, 2, 3, 4, 5, 6* in order, their bellies up, on each side of the glued central block 204. Each rib is glued and nailed directly to the spars by two 20mm nails 230.

The two innermost ribs are spaced 400mm apart; the others 300mm *(fig. 4.1)*.

Turn the whole thing upside-down and fit the blocks 233 with plenty of glue between the ribs and the spar caps. Then nail them so all the rib bellies are parallel, checking with a spirit level 234.

Glue and tighten by their threaded rods the plates 205, 206 *(fig. 4.2)*. These plates are level with the ribs above and below the wing. Glued parallel to the inner blocks 213, these reinforce the spar caps, which are pierced through here by the threaded rods. The wood of these plates must be excellent quality with perfectly straight grain.

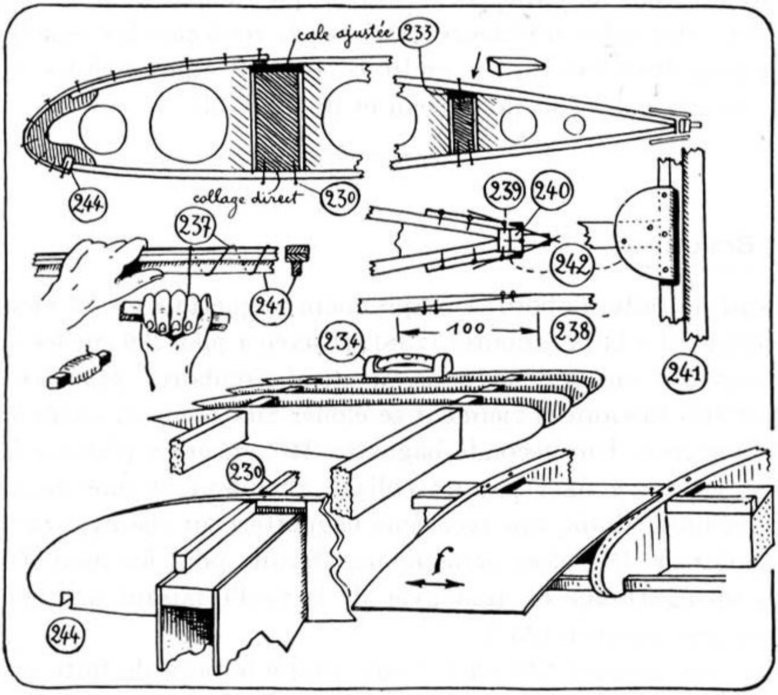


Figure 4.6: Assembling the wings

4.7 Leading and trailing edge

Trailing edge first. Take a first strip of wood 6×12, scarfed if necessary (238), and fix it flat (239) on the tails of the ribs between two half-circle gussets (242). The two beveled ends are nailed to the ends and back of the main spar. A second strip (240) is placed flat on the first and held with plenty of glue and a dozen fine nails. Finally, a third strip, placed on its edge, reinforces them. Nails alone are not sufficient to hold these; they must be tied with string, making a turn every 30mm or so (237).

A large 1.5mm plywood gusset unites the trailing edge with the ends of the main spar.

If you fear that the strips may break in bending, especially the third, moisten them with a damp cloth for 5 minutes before you fit them.

4.7.1 Leading edge

A 6×12 strip is laid from end to end in the notches (244) cut under the nose of each rib. Pieces of 6×12 strip are then placed on edge (230)[2] between each pair of ribs along the front of the spar. Then wrap the rounded top of the ribs with 1.5mm plywood, the grain of which should run along the wingspan, gluing from (230) to (244). It is wise to only cover one bay *(i.e.* 300mm) at a time, either butting the plywood sheets at the middle of each rib, which gives 6mm gluing area for each, or by overlapping slightly beveled edges; *i.e.* a scarf joint. This covering must be very firmly bonded, so we advise against covering three or four bays with a single sheet of plywood. If

[2]This refers to (230) at the bottom of Figure 4.6, not the one at the top.

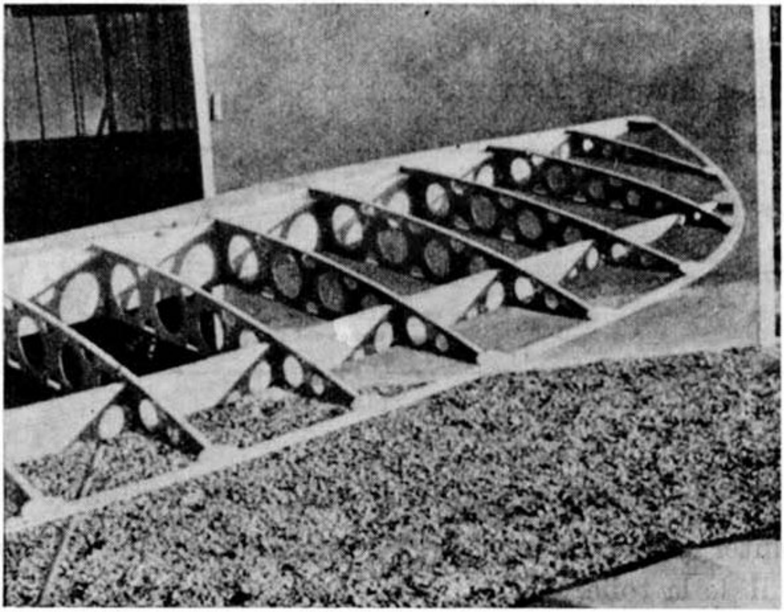


Figure 4.7: The finished wing structure

the ribs are not perfectly aligned, this would create dangerous voids without sufficient bonds. Remember that this plywood portion alone carries as much weight as the entire area behind the spar. For that reason, cover it as if there were no plywood underlying the fabric.

After it dries overnight, remove the string and smooth, shape, and polish the outline with the file.

The fuel and oil tanks are placed in the forward wing, between the center two ribs, a 15L one in front of the

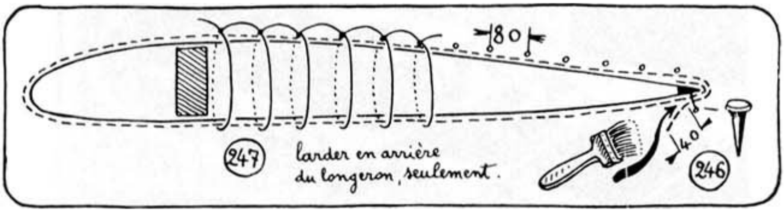


Figure 4.8: Covering the wing

spar and a 20L one behind. This gives a total flying time of about 5 hours and a range of 500km, barring wind.

The tanks are placed on 3mm plywood floors 245, glued and screwed under the center ribs, spar, and leading edge. They are then blocked into place and covered over.

The front and rear wings weigh 15 and 10 kilograms, respectively.

This is the moment to photograph them, because I hope you will not see them thus again for a long time. The photo is a good memory, and you are welcome to send them to the author as a testimony of our friendship — he will be delighted!

4.7.2 Covering

The fabric is usually sold 1 meter wide. For the forward wing, we will use a sewing machine to join 6 strips, 3m 20cm long, at their edges.

Wrap the wing chord, leaving the free edges at the trailing edge of the wing *(fig. 4.8)*.

Fully tighten the belly side by tacking the edge of the cloth around the trailing edge:

i. Tack the cloth between the ribs *1*.
ii. Tack to rib *6*, stretching between *1* and *6*.
iii. Tack (about every 40mm) between 1 and 6, straight along the weave of the fabric.
iv. Tack with four nails at both wingtips, stretching very tightly.
v. Tack between the wingtips and the ribs *6*, stretching very tightly along the wingspan.
vi. Stretch the belly cloth tight by pulling from the leading edge, and tack with one nail at each rib nose.
vii. Flip the wing and tack the top surface (free edge folded and tacked on the belly side as shown at 246), pulling with all your might, and following the same pattern as for the belly. Use tweezers to avoid bending your nails...

Finish with the rounded part of the leading edge.

Nailing is more easily done with the wing upright on its leading edge — sweep the floor well so nothing injures the plywood! A helper[3] holds it upright and simultaneously holds the nailbox for you. Climb on a 200mm stepstool and stand on the opposite side from the nailing[4].

Do your covering in hot, *dry* weather, or in a *dry*, heated room. In wet weather, if you try to stretch... a ray of sun touches the wing, and you must begin afresh! Cut away the excess cloth, leaving a margin of 40mm after nailing.

Since our wing is now bagged like a mattress, let's stitch it up like one. Stitch 247 along each rib with good hemp

[3]Or a stand — Translator

[4]Maybe M. Mignet means, *get right across from your work*, as suggested by the Air League. — Translator

string (Bessoneau N° 8), and a mattress needle 22cm long (Bazar Hôtel-de-Ville), knotting the string on the top of the wing every 80mm, but not cutting the string between the knots. Tighten well as you go. Thanks to the dihedral of the wing, these stitches tighten the fabric very much.

All around the tips and trailing edges, the 40mm margin must be glued with cellulose varnish, wetting the fabric above and below. Let dry completely (5 or 6 hours).

4.7.3 Varnishing

Choose a warm, dry, sunny day. Work outside, in the shade, in the afternoon. Put the 20L can of cellulose acetate on a chair. Fill a small pot of this varnish, and loading the 60mm fishtail brush, apply the coating by wetting the canvas so it becomes translucent. Spread the excess around with additional brush strokes.

Don't economize on varnish; it's not there to look pretty, but to give the fabric body.

Proceed gradually front to back, rib by rib. Before moving on to the next strip, smooth out any runs that have formed, but don't worry about it too much.

In wet weather, the layers grow milky from condensation. Try not to work in such weather.

If it is warm, you can start the next coat two hours after the last brushstroke. Three coats is enough; an additional layer on top is better. After the first coat, lightly polish the entire surface with fine sandpaper — very effective.

Seams, gluings, and stitches must be covered with pinked tapes. The area is wet with varnish, then the tape, which is brushed into place, soaked with varnish. While it is drying, make sure the pinked edges do not curl up. Smooth them by rubbing with a cloth. Before the brush dries,

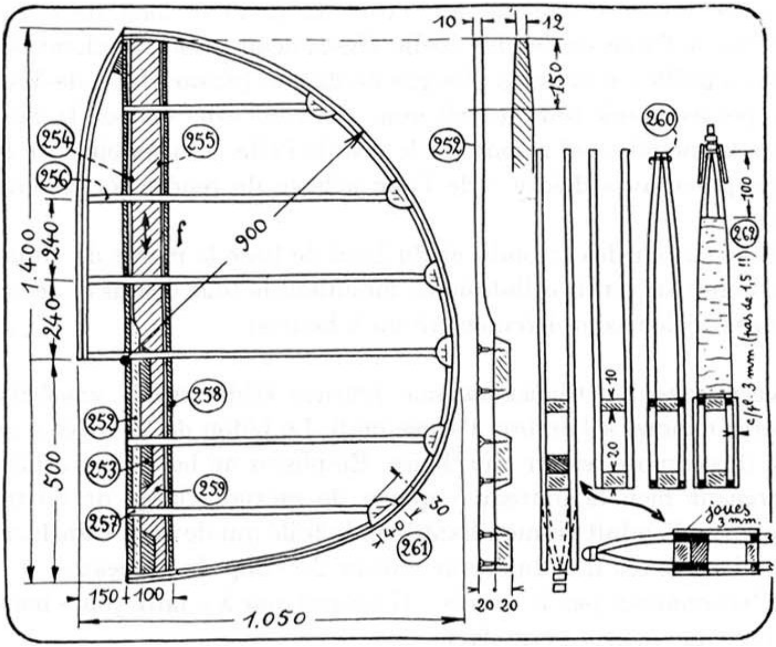


Figure 4.9: The rudder

wash it with soap and water. The varnish will come off in little white bits.

In the previous edition, there was a question of a little skylight to see through the wing above you. Don't bother with it.

4.8 Rudder

The rudder is of monospar construction *(fig. 4.9)*.

A 20×20 stick (252) with hardwood reinforcements (253) is thinned as at (254) to 20×12. It and a 20×10 slat (255) form the spar caps. Each 200mm, nail on the 6×12 strips that form the ribs. The upper ones extend beyond (256) the spar, forming the leading edge and acting as a slight aerodynamic balance. The lower ones (257) end with the spar. Place between the ribs 6×8 strips (258) along each spar cap on both sides, and cover with a strip of 3mm plywood (259) 100mm wide and 1400mm long, with the grain along its length. This strip extends beyond the two narrow ends of the caps, 12mm. In the channel thus formed run two strips of wood chosen for their straight grain, soaked for 10 minutes and bent, then bound with plenty of glue after being nailed to the rib ends as in (260). Just like the trailing edge of the wings, the edge is secured to the rib tails with gussets (261).

A 1.5mm plywood web (262) stiffens each rib.

Cover the rudder just like the wings and apply 4 coats of varnish.

Time: rudder 4 hours, covering 1 hour; weight: 2kg.

Now is the time to paint a beautiful emblem on the rudder. It is the signature of the amateur, and displays the craftsman's taste and originality.

A good emblem is like lipstick on a pretty woman — it completes the *toilette*; it is the stamp of seduction.

The airframe is finished. What remains is the fitting of the engine, without which, like a face without eyes or a

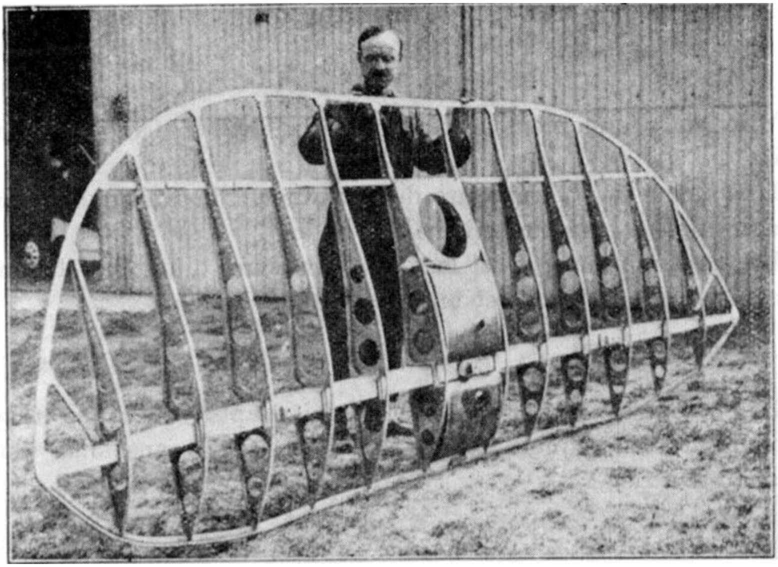


Figure 4.10: M. Mignet with a wing of the old style, 4m in span. The rear wing is identical except for the fuel tanks and the little window. This wing has ribs in the old unsafe airfoil, and is shown to illustrate the overall wing assembly.

body without a soul, it would be good for nothing.

Chapter 5

The Engine

Whether used for war, tourism, or sport, a suitable engine is the essential basis of any aviation, no matter how aerodynamically sound the aircraft is, even if it is a training glider.

Bad engine: failure. Good engine: success.

The foundation of my aeronautical exploits on the HM.8 was the motorcycle engine, unbolted from its frame and mounted on the fuselage to drive the propeller via reduction drive. My amateur proceedings could supply nothing better.

It is possible that we may come back later in our 100% amateur proceedings with additional advice — but for now, let's move on.

At the time my flights were mere cricket hops — barely 5 years ago — I begged a motorcycle manufacturer to assemble a 500cc two-cylinder opposed engine on the same crankcase as his mass-produced motorcycles, which were proven to be excellent. This engine would have provided 25hp at 40kg for 3000 francs. I was asked to contribute half the expenses, which rose to 12000 francs. If I could have agreed to pay half, this engine would have won the laurel in all Light Aviation records. Popular aviation would be four years ahead. Who knows where we might be today!! I know it. we would be today where we will be in 4 years, perhaps not in France, but abroad where the Light Aviation movement is a redoubtable force. And all that lost by hesitation, by smallness of mind, by laggardliness.

I did not have 6000 francs to spend, and the manufacturer decided to pursue a different project, a 4-cylinder *monobloc* engine for light aircraft, of their own design, as mine were too rustic. . . an marvel of mechanics which could barely produce half the intended power and almost bankrupted the company.

Planting to harvest. . . be patient. . . I stuck to it.

I next had the pleasure of meeting René Poinsard, to whom I related the basic ideas of my article on engines from *Les Ailes* n° 511, April 2, 1931; in it I had called for a 1000cc flat twin of 25hp, with staggered cylinders, lubrication by circulating oil, etc. . . I'm not saying I created the Poinsard-Mengin engine, but I do congratulate its author on having chosen a formula well-proven elsewhere and turned to our purpose. Instead of being drawn on by the craze for novelty, he relied on sane judgment, and can thereby rely on years of experience.

My old two-stroke was wind-broken, and a single-cylinder four-stroke couldn't produce more power; I left for the *Salon de la Motocyclette* (October 1932), having stuffed my briefcase with the details of the HM.8, well illustrated with photos. It didn't take me long to find the Aubier Dunne booth with the 500cc two-cylinder two-stroke, well-known to my amateurs, in front. We quickly came to an understanding, and a few days later, the Bois de Bouleaux heard their engine humming. They came out to my field often to test and tweak the engine. There were problems, they plied the wrench and file, and finally the goal was achieved. The engine ran well and could produce 20hp indefinitely.

For three years, I was able to fly thanks to Aubier and Dunne.

When called by the big English paper, the Daily Express, to demonstrate the Pou-du-Ciel to the British, I was preparing to cross the English Channel, I had a failure of the four-stroke engine I was using. I didn't hesitate, in my embarrassment, but went straight to Aubier and Dunne, and left without a worry to cross the Channel, even though the engine was factory new. — Overconfidence? — No. — Confidence born of experience, in an engine I knew to be faultless.

Other engines came along as the "Pou fever" spread, and the amateur, having completed his machine, was at the point of mounting the engine. I was deluged with questioning letters: Which engine should I choose? What do you think of *this* engine? — I was just getting to work on these novelties myself.

These new arrivals made me as welcome now as I had been ill-received when I was making my first cricket-hops. I must take this opportunity to thank these manufacturers for their courtesy and their broadness of vision. With no view toward competition, they placed themselves at my disposal in a spirit of frank collaboration. Because of this, I was able to answer the amateurs' queries with certainty, having flown behind the main engines myself.

Shall I here compare their faults and virtues?

This afternoon, I flew a long time with first one, then another, and then a third. I have 4 Poux-du-Ciel in my laboratory, ready to go, fitted with different engines. This one has a bit of trouble taking off, but is excellent at cruise, and burns but little fuel. This other consumes more fuel, but doesn't vibrate at all. This last makes less noise and climbs like crazy. Which is the best?

Why does one man buy a Citroën, another a Peugeot, and another a Renault? Which car is best? Who is right?

There are enough customers for all these engines to go around. Each company has a right to its time in the spotlight, and they will get it if they produce merchandise of the quality the public expects and that their advertising promises.

Therefore, I cannot say that one engine is better than another one. They are *different*, is the essential point, and they meet different requirements.

All that being said, light aviation has gained, thanks to the Pou-du-Ciel, suitable engines. That essential point achieved, the rest is patience, perseverance, and planning on the part of the amateur, and goodwill on the part of the government.

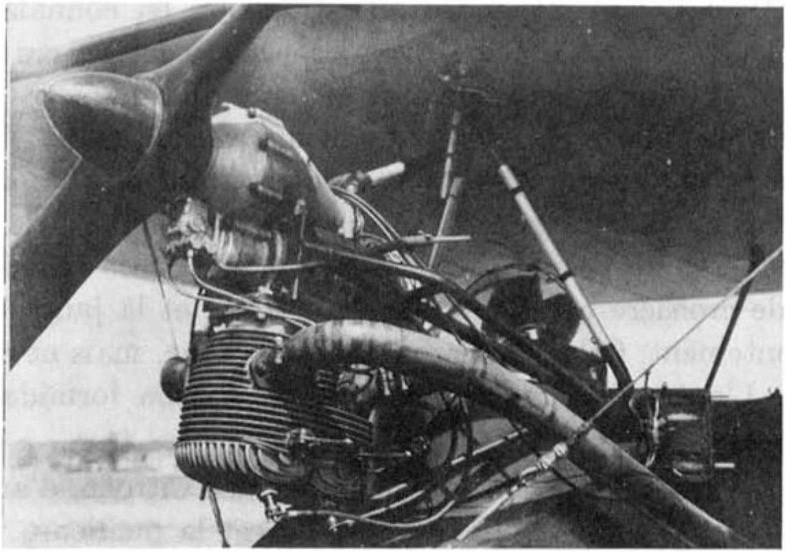


Figure 5.1: The 540cc *Aubier et Dunne* "Channel" model

5.1 Some good engines:

(M. Mignet begins by discussing some fine engines whose relevance is limited to his time. I have included some of the illustrations, for the assistance they may provide in devising engine mounts for currently-viable engines.)

So, we must choose an engine. A fight is brewing between 2- and 4-strokes.

The two-stroke has in its favor its extreme simplicity, as long as it remains comparable to a motorcycle engine

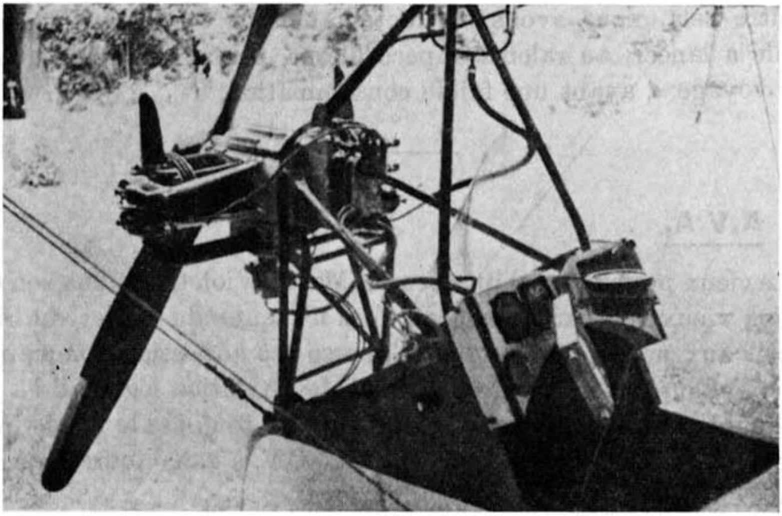


Figure 5.2: The 25hp Poinsard-Mengin

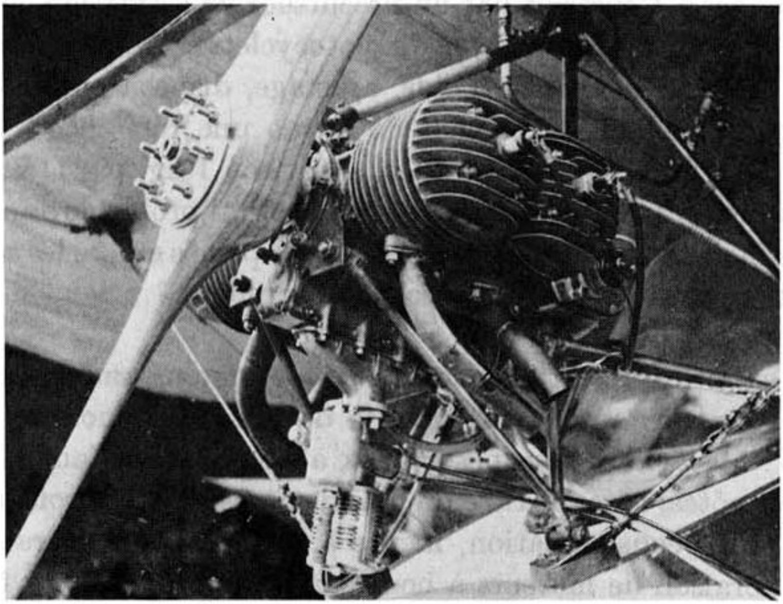


Figure 5.3: The 25hp AVA engine

and is not loaded down with too many accessories. It has but one main defect — its poor idle — and it has the advantage, for the amateur, of being very affordable.

I wish all these engines would have one thing in common: that they would turn the same direction, and have the same propeller hub! *Naïf* that I am! Do you think manufacturers past and future want their engines to be compared in power using the same propeller? Still, we are fortunate there are only two directions a propeller can rotate; if there were seven, we would have seven engines rotating different ways! Apparently paying customers are entitled neither to idle comparisons nor technical discussions…

Finally, I would insist on the following points:

An engine must:

i. not vibrate in flight — essential for comfort and safety
ii. stay clean — big selling point!
iii. feed from tanks placed at the height of the propeller axis
iv. have carb heat, to counter icing in winter
v. have exhaust ports as low as possible
vi. have its mounting plate free of accessories
vii. have a variable or automatic ignition advance, or a magneto, to allow a safe departure; or have a starter, allowing even the weakest woman access to what will become her favorite sport: Light Aviation.

5.2 Power

As regards the Pou-du-Ciel, 25hp appears to be plenty of power. At cruise, the Pou is happy with 14 or

15hp; ten horsepower more ensures a satisfactory take-off and a service ceiling around 2000-2500 meters.

A more powerful engine (for the beginner) is worse than useless; it's dangerous. If the aircraft is badly balanced, it will still fly and climb, but when the pilot cuts power, he risks finding himself in an unrecoverable situation.

We need not a powerful engine, but a *faultless* engine. The one who shouts into every wind, "Engines! Compressors!" may be right when he addresses the sellers of flying gunships, but in private aviation, popular aviation, safe aviation, this poor inexperienced fool is talking nonsense.

The 1936 Pou-du-Ciel demands a *continuous* 20-25hp, not 35 rabbits. This engine should provide its power between 1500 and 2500 rpm, weigh 30 kilos, and cost 3000 francs.

Why do you hesitate, manufacturer? You know nothing of aviation. If there were no engines, there could be no motorcycles; likewise, there are no small airplanes because there are no engines.

Do the math, and you'll see that in four years you will have sold forty thousand engines... Are you decided? Or does it give you a tummyache?

May the good Lord bless you, or the Devil take you... so be it!

5.3 Thermodynamics

A few words about fuel would not come amiss.

Ignition of an explosive mixture quadruples its starting pressure. The initial compression of 4kg/cm^2 produces when ignited a pressure of $4 \times 4 = 16$kg/cm^2. 8kg/cm^2 produces 32; 16, 64; and so on, if it were possible.

A motor produces more power as it rotates faster and its compression ratio increases. But... there is a limit.

Very soon the mechanical elements can no longer obey. Friction absorbs any increase in power.

Too much compression, and the fuel-air mix *detonates* before the desired moment, producing a violent force that would break the strongest engine.

Therefore, when we raise the compression ratio, we must provide the engine with a specially-formulated mixture to ignite as late as possible. It's a problem of chemistry.

The normal mixture of air and gasoline detonates at a compression of 4 or 5.

Alcohol very effectively prevents detonation; it is therefore a question of mixing it with gasoline. But alcohol attracts water, and water is the enemy of gasoline! Such a mix becomes possible if the water content of the alcohol is minimized and a binder added to overcome the effects of the last traces of moisture. Such binders include benzol, ether, and butyl- and amyl- alcohols, among others.

An example proportion: 80% gasoline, 10% alcohol, 5% benzol, 5% oil.

The proportion of alcohol may even exceed 25%. Benzol can also replace alcohol. There are even some mixtures that contain no gasoline at all — 100% patriotic fuel! With olive oil, alcohol, and other locally-produced ingredients, we will no longer be dependent on foreigners.

But that's another story entirely, and the owners of oil wells don't want to think of nationalism with regard to our engine power…!

Heavyweight motor oil works wonders for a high-compression engine. Don't disdain them.

Finally, there are anti-knock products on the market that you can add to your gasoline in a certain proportion.

5.3.1 Drawbacks

In cold, wet weather, mixtures of gasoline and alcohol tend to separate. The heavier alcohol settles to the bottom. If there is oil mixed with the fuel, the oil floats on top of the gasoline, and the engine, running on pure alcohol, is no longer lubricated — it will seize up forthwith.

5.3.2 Anti-detonation coefficient

Two liquids with opposite qualities go into these mixtures: heptane, which promotes detonation, and octane, which prevents it. This mixture ignites at a known compression, for a specific mixture: for example, 20% heptane and 80% octane. The mixture is called 80 octane. Any other mixture, of gasoline, benzol, alcohol, or whatever else, of a proportion which ignites at the same compression, is likewise called 80 octane. This is a comparison index.

For example, ignition at compression of 4 indicates 69 octane; at 5, 72; at 6, 75; etc.

A lot of people talk about octane numbers without understanding what they're saying, and mechanics don't understand it either. Beware the octane ratings you see advertised.

Just like in photography, a good practice is to use the fuel and oil recommended by the engine's manufacturer, and to not depart from it.

Avoid custom blends, untried innovations, and above all, the advice of your friends. When in doubt, ask the manufacturer.

Gasoline is to an engine as mushrooms are to a man: one is life, another death. Remember that everyone is selling something.

Be certain not to confuse

detonation and preignition:

Detonation: The fuel mixture ignites explosively, all at once, at a certain compression. The engine clicks.

The sound of detonation is like a steel ball bouncing off of ice. It is dry and pungent, and very distinctive. A detonating engine is about to stop running — it is about to fail. Reduce power to cool it, or look for some alfalfa for your wheels!

Preignition: The fuel mixture ignites, aided by the heat of compression, but in contact with a part of the combustion chamber that is too hot: a hot particle of carbon or lead, a red-hot spark-plug tip, the poorly-cooled surface of a piston. The engine knocks. Auto-ignition is less brutal than detonation, which overheats and shocks the engine more than anything, but it can cause the engine to quit without even a bump. It gives the impression of a seized piston.

This brings us to spark plugs; fast-turning, high-compression engines are sensitive to spark plugs. They need "cold" plugs, whose very close electrodes are heavy and diffuse their heat to the outside or to the mass of the plug by their good heat conductivity. The magneto permits easy starting despite these spark plugs. Keep to the type of spark-plug the manufacturer recommends — *this is an absolute law.*

5.3.3 Carb jet

The carb jet must be larger in proportion to the weight of the fuel; here is an example for some particular engine:

Benzol	jet	140
Normal gas	—	180
Heavyweight gas (25% alcohol)	—	240
Pure alcohol (en course)	—	300

5.4 Purchasing an engine

When I advise you to buy a new engine, I'm assuming that you have the necessary 4000 francs. Perhaps that money will show up one day, if you consider your hobby worth it, or if some outside investor is impressed enough to allow you this purchase.

Maybe before you neither wanted to nor were able to risk so much on a mere hobby.

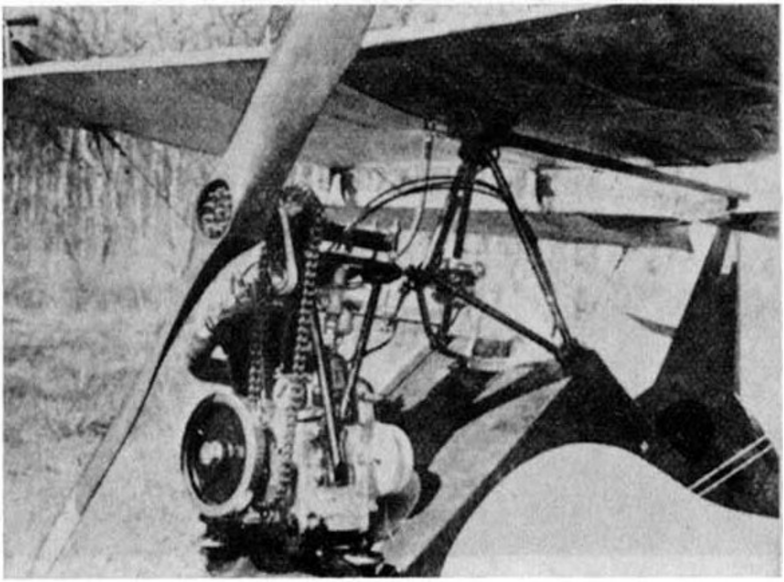


Figure 5.4: The standard 500cc Chaise. It flew 50 hours in Rul's HM.8.

You may have preferred to buy an engine second-hand and toss it out later, replacing it with a better-made one.

It is necessary to define our situation.

According to the letters I got about the HM.8, and my own tribulations, it appears that all engines of good manufacture are about equal, over about 500cm^3.

Among the old two-cylinder V's, Harley and Indian are second-bests. They cannot be inverted. Harley is the most serious.

The more recent 500cc single-cylinder four-strokes are workable, preferably without a reduction unit. They give from 17 to 20hp at about 4000-4500rpm. Some examples: JAP, Sturmey (English), DS (French). They can be inverted, modifying the oil system as needed.

Unless you find an exceptional opportunity of great quality, don't spend more than 1500 francs. There are, of course, opportunities; A modified Harley costs 1000 francs; an Indian, 600. They weigh 45kg — that's heavy. Expect 12 kilos of accessories — prop, reduction gear, engine mount — to complete the firewall forward installation.

I would despair at seeing you spend 3000 francs for a new non-aircraft engine!

The used engine, a real bargain, will suffice to get you started. The worse it flies, the better pilot you will be come, but a trip around the patch is the most you will be able to do — if you make it.

Figure 5.5: Another inverted motorcycle engine... and its very good-looking pilot!

5.5 Mounting

The inclined triangular platform of our fuselage makes it very easy to install any sort of engine.

We will study two cases:

A. You have purchased a light aviation engine, planned, suited, and perfectly tested, as was discussed above.

   No waiting, no studying, no risk.

   The manufacturer will supply an engine mount suited to and tested with the Pou-du-Ciel — usually with my approval.

B. You have a used engine.

   Does this engine put out enough power to make the Pou-du-Ciel fly decently?

   Here are some data so you can figure it out right away.

   All you need to look at the number of revolutions per minute it will give with the propeller described in the next chapter.

   Test the propeller at a static point, in RPM.

1350	Flight barely possible at high angles of attack. Slow speed. The engine will heat up and not hold up.
1400	Takeoff is difficult. Must be light.
1450	Takeoff is easy. At cruise it is possible to reduce the throttle a little. Will the engine hold up?
1500	Good, but it could be better.
1550	It's a good start.
1600	Climbs at 2m/s. Reaches 300m in 3 minutes. . . cruises at $\frac{1}{2}$ power. Life is good! Humanity swarms beneath your wheels.

That being said, and to test my data — who knows? maybe your engine is amazing — this is how to proceed:

The engine mount which is given here is a welding job. A professional can do it easily; make sure you prepare the pieces in advance. If welding is unavailable to you, replace the tubes with angle iron 3×30mm, riveted, with fittings modified to suit. Rivets may be made of 6mm drawn rod. It's a provincial second-best.

Strive to place your engine upside-down, "inverted", with the thrustline *parallel* to the top rear and aligned with the centerline of the fuselage, turned neither to the left or to the right.

Keep it as low to the inclined platform of the fuselage as its size allows, taking care that the front face of its housing — the conical tip of the shaft — is directly above the front point of the fuselage, with the axis of the motor horizontal.

The crankcase mounting flanges will be tightened by bolts (10mm threaded rods in the case of the 540cc Aubier and Dunne, which we will take here as an example) between the flanges (267) made of 2mm sheet metal (*figures 5.7, 5.8)*. Ensure that the ears (268) are parallel.

Add to this a 16×20 tube (269) in such a way that, welded to the two flanges, it falls into the fitting (191) at the feet of the cabane. It will be good to heat this tube red and bend it slightly, so that it meets the fitting squarely. Fit the end of this tube (270) onto the front flange, trace the meeting points, and take it to the welder.

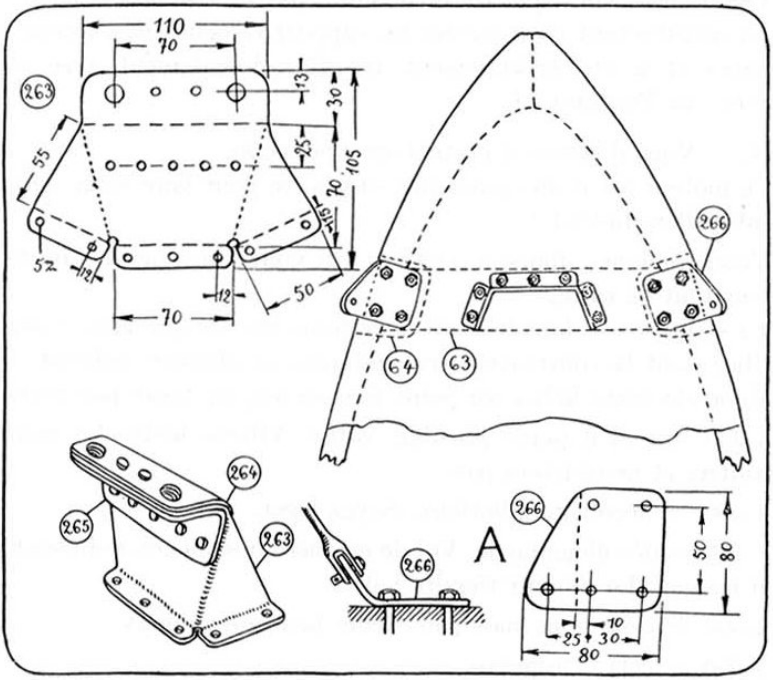


Figure 5.6: Engine mounting details

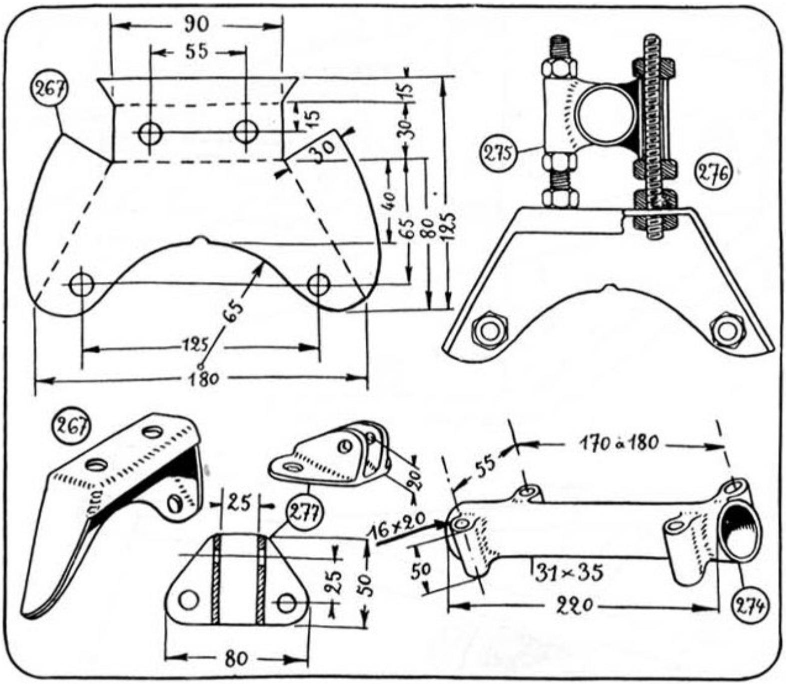


Figure 5.7: Engine mount fittings

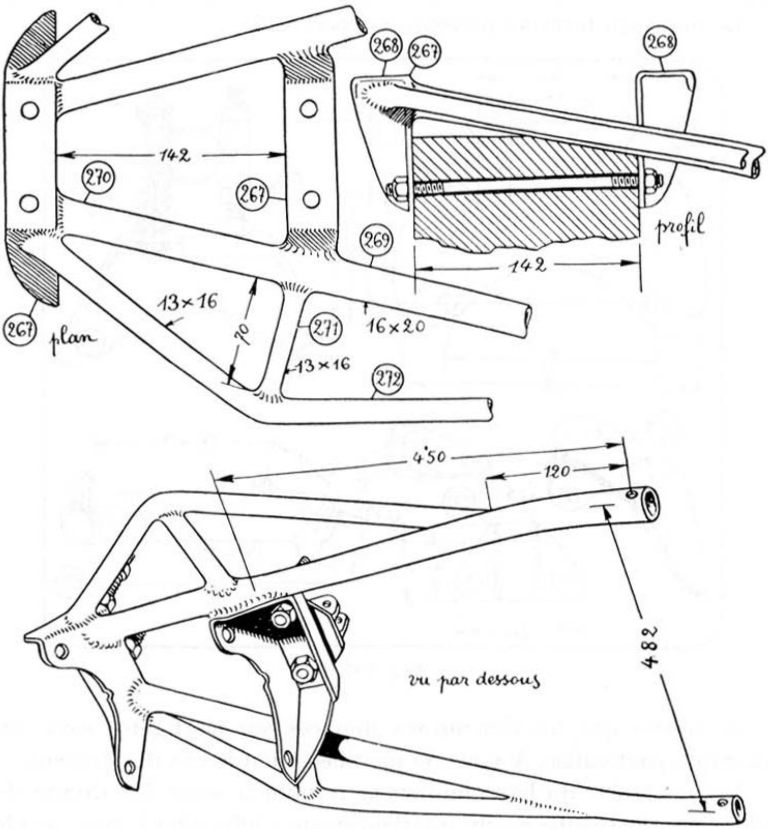


Figure 5.8: Engine mount — arrangement

Bolt it back on the crankcase.

The welder will attach the tube to the second flange *in place*. Protect the engine with rags soaked in water, placing them around the weld as soon as it is finished.

Remove the whole assembly and form a triangle with the spacer (271) and the tube (272), whose end is near to fitting (191) and will be welded last in place, 100mm from the fitting.

The finished engine mount is shown at (273)[1].

I repeat: the dimensions given in the figures are for one particular example; it is up to you to modify them according to your case.

The feet (297) of the engine mount are terminated according to (298) (filled with hardwood), (299) (tube welded internally), or (300) (2mm tube welded externally). The latter way is best. They are fastened in the brackets (191) of the cabane legs by a 7mm bolt.

This assembly is intended to control the engine's side-to-side oscillation.

The engine will be supported on the other hand by two 16×20 tubes welded or bolted on each side, somewhere on the crankcase or on the flanges (267), with their feet welded on the wing bracing fitting (266) on the inclined platform. That way, the engine is secure, completely triangulated.

If, when running, you see the cylinder heads vibrate laterally, use their fastening bolts to attach them to the rods that are connected rigidly to the fitting (266).

The piece at (263) is the old support for the 540cc Aubier

[1] Which does not appear, but refers to the lower drawing in Figure 5.8.

and Dunne, inverted and fastened to the two rear breech bolts.

5.6 Propeller shaft

At what speed does this used engine you found normally run? Would it work to just stick a propeller on it, direct-drive? Has the pull of a propeller been planned on its bearings? Of course not.

It's much easier to use the propeller made by the book by powering it like a motorcycle wheel, using a reduction drive whose ratio will be determined empirically, without risking damaging the engine.

M. Mignet goes on to give details of a straightforward but ultimately terrifying reduction drive that he hopes might go 12 hours between failures.

Chapter 6

Pou-du-Ciel 1936: Centering and Balance

Behold the most important chapter of the book! To build a Pou-du-Ciel is futile unless you observe the following instructions — unless you propose to kill yourself.

The center of gravity of the machine must be located somewhere on the vertical of the resultant thrust[1] of the two wings when the aircraft is in a level flying attitude.

If the center of gravity be considered static, the correct balance will be obtained by advancing or moving back the front wing.

We begin by mounting the two wings, which both pivot in opposite directions, the rear wing being fixed

[1] This wording, *poussée résultante*, is unclear.

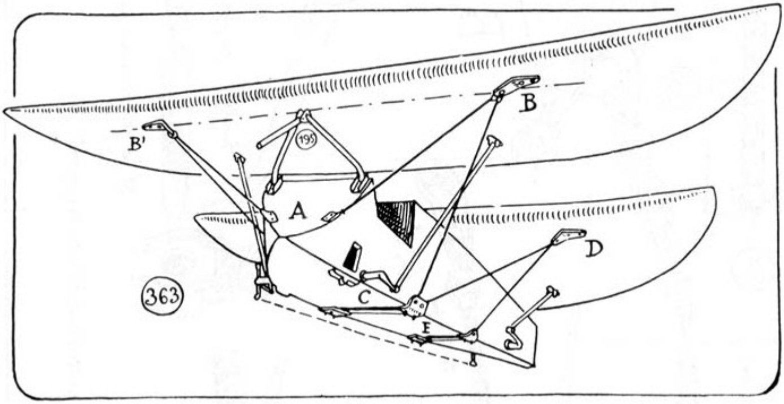


Figure 6.1: Arrangement of bracing wires

in its final location.

6.1 Wing Bracing

363 in figure 6.1 shows the plan and layout of the bracing wires, which are triangulated tetrahedrally (*fig. 6.2*, 364), so as to be dimensionally stable in tension.

6.2 Rear wing

A threaded rod 197, 200mm long, secures the U-fitting 198/199 under the middle of the front spar of the rear

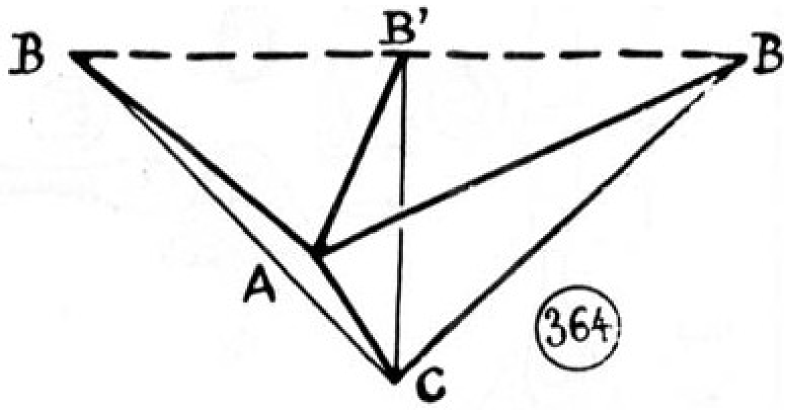


Figure 6.2: Tetrahedral bracing

wing. The fittings **B** fixed by the two bolts 365 have been cut and bent so that their eyes, by which the stay cables are attached, are aligned with the axis of the pivot attachment 195, as shown in exaggerated form at 368. With a tautened wire, it is easy to determine the height 369 *(fig. 6.4)*.

The axis of rotation 195 for the rear wing is held between two brackets 188, which are fixed to cross-member 85 of the fuselage by two 6mm bolts *(fig. 6.5)*.

The fittings **C** are fastened with 5mm bolts under the fuselage where the 20×20 members are reinforced with hardwood 37. Connect them with strip of sheet metal 1mm×20mm.

Attach the rear wing to its pivot, using a 7mm bolt through the tube 195. Temporarily fasten the 1.5mm wire from **B** to **C** so the wing is held horizontal, with

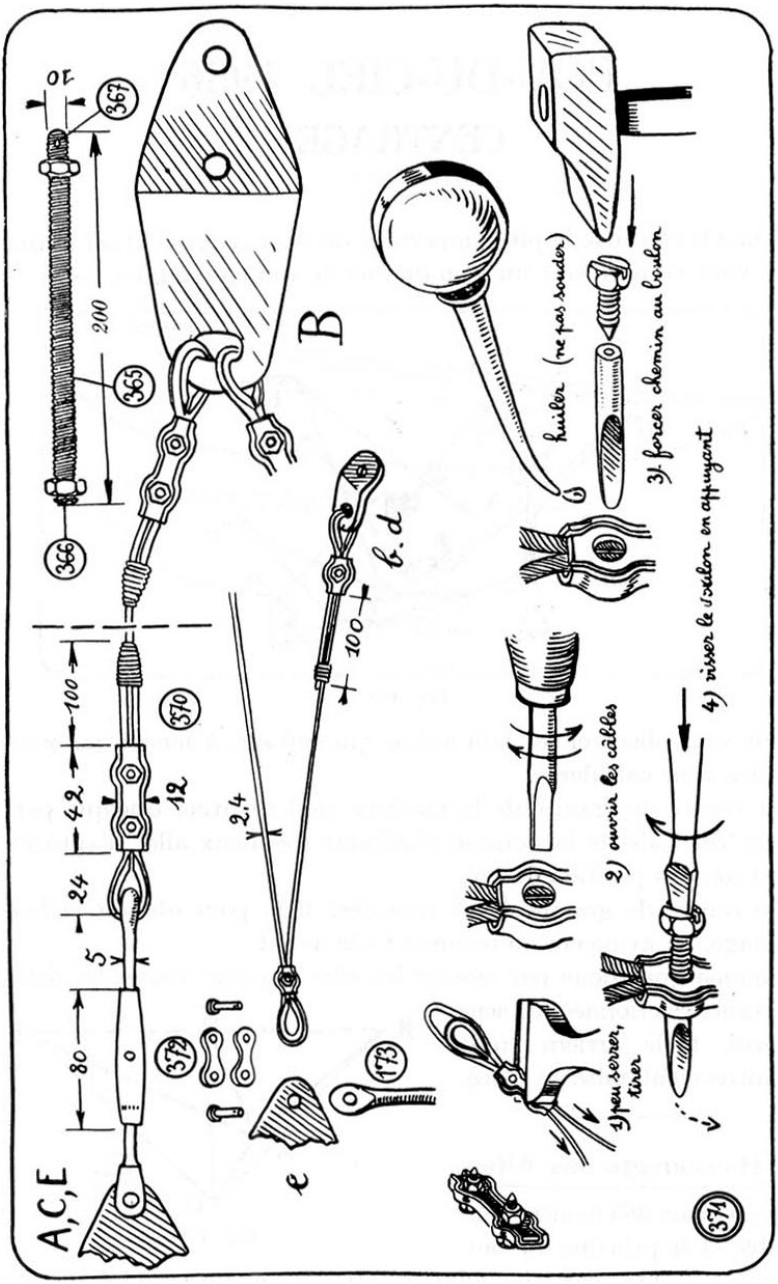


Figure 6.3: Details of bracing

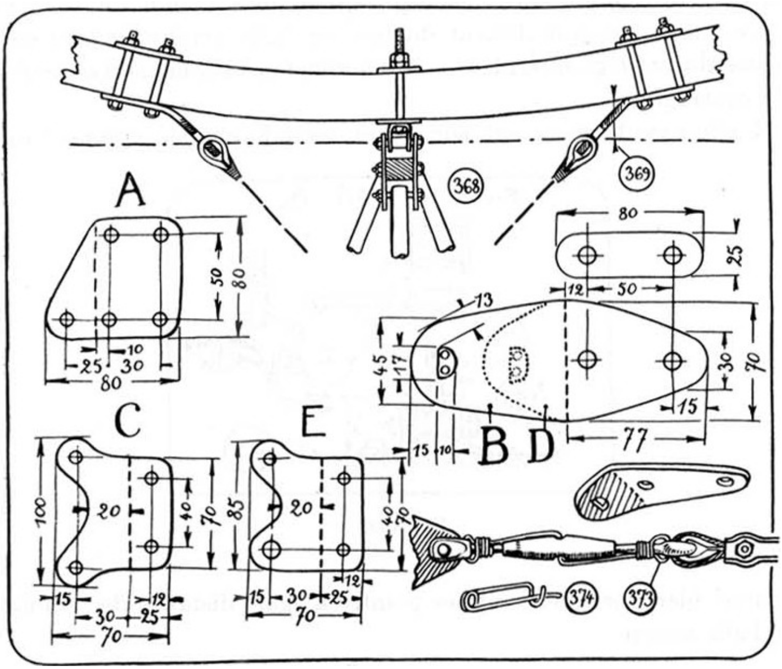


Figure 6.4: Layout of front-wing bracing

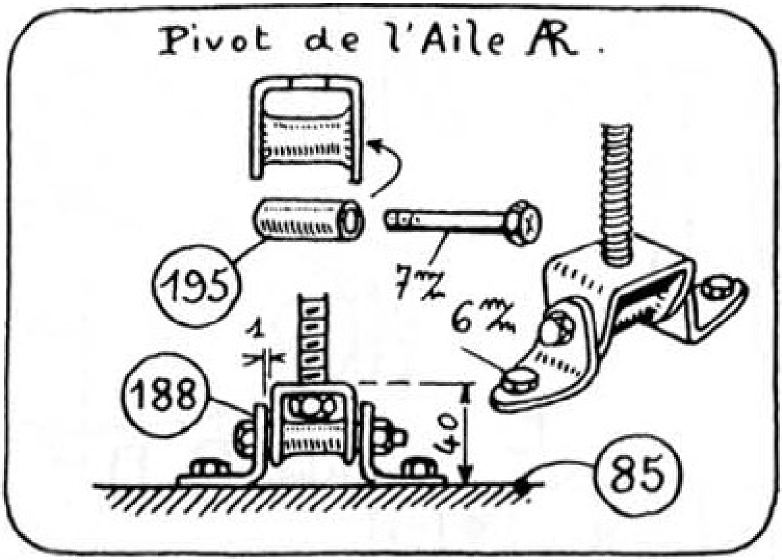


Figure 6.5: Rear-wing pivot

its tips equidistant from the front point of the fuselage as verified with string.

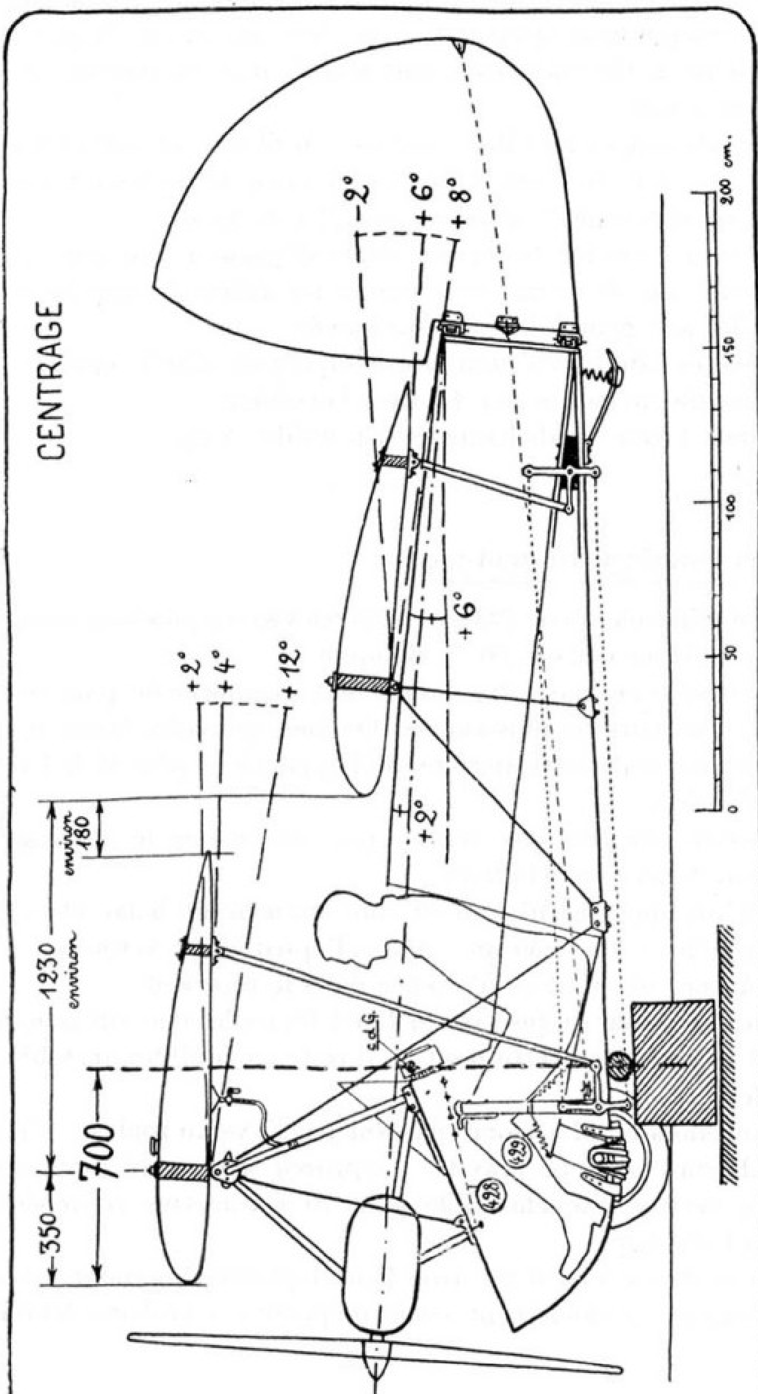
6.3 Front wing

The top of the cabane is held in place by the tube 194, fastened at the other end to the engine, so that a plumb-bob from the axis of the pivot 195 falls 123cm ahead of the nose of the rear wing, with the fuselage supported so the top of the turtledeck makes a 6° angle from the horizontal. (See *fig. 6.6* for a complete diagram of the centering.)
The front wing should be placed on its pivot and braced like the rear wing: perfectly horizontal, with its tips equidistant from the tips of the rear wing.

6.4 Bracing wires

At this point you may determine the precise lengths **AB**, **BC**, **CD**, and **DE** between the holes in the fittings, so you can prepare the final guy wires as shown in detail 370.
Everywhere there are 5mm rods, 5mm cables. It is clearly unnecessarily solid in some respects, but hardly heavier — and it's probably best that the Pou-du-Ciel not fall apart in the air!
When the fitting **B** is removed, prevent the wing from falling by placing a support under the opposite side so that the wires on that side are tautened.
Install the eyelets as at 371.

Stop-wire the turnbuckles with a 1mm wire 373 wound 5 times at each end after passing it through the eyes


CENTRAGE
-2°
+6°
+8°
+6°
+2°
+4°
+12°
+2°
environ 180
1230 environ
700
350
c.d.G.
428
429
0
50
100
150
200 cm.

and clevises. The axes of tensioners and links will be immobilized by pins 374 of 1mm steel wire.

Before cutting the cables, tie in strong wire on both sides of the cut, about 6 or 7mm. Cut with a blow from a hammer on a cold chisel, holding the cable against a sheet of steel plate.

Bind all cable ends that extend beyond