

Extracts from

# Aerial Sport

How and Why I Built the Pou-du-Ciel

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(translated by Jason R. Fruit)

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# Chapter 1

## HOW I BUILT MY POU-DU-CIEL

*If you can nail up a shipping crate,  
You can build a Pou-du-Ciel<sup>1</sup>.*

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.

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<sup>1</sup>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 planes; without which the public would never have seen at the 15th Aeronautical Exposition in 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!)

- An combination of simple elements that appear complicated.
- The ordinary structure with no precise adjustment, which nonetheless requires that nothing distort.

## 1.1 Material

The forest. A tree.  
Cut down. Sawed. 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 a 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 lose a piece of yourself. . .

You have no emotional attachment to a plaster-of-Paris statue, to a car, made 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 crafted material is alive and sensitive, entitled to a *caress*.

What will be its destiny? Over what clouds, what valleys will it soar? To which 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 her. 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<sup>e</sup> salon de l'Ã‰ronautique 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 client le, 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'm no longer 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-bĀt'bĀt' 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 hasten to create a counterfeit Pou-du-Ciel, to turn my efforts to their gain, 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.

The honor is preserved by keeping the Pou by 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<sup>2</sup>.

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, not just its available power: 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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<sup>2</sup>The meaning of this passage may have been mangled in translation.

## 1.3 Prudence

All that flies must, in essence, 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 get away! 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 lose 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, as in factories. What good would it do? Everything is specified already In the small scale! If you do not know to read and understand them, you don’t have the skill for this. Do not begin construction — 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 roofing structures.

The dimensions used are in agreement with its strength. If you find American wood, Spruce, Oregon, 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, *eg.* in the guying 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 Visibility

The Pou-du-Ciel is a simple design.

The most basic prudence dictates that one entrusts one's 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 cabin is an empty box. Inspection is possible.

## 1.7 Controllability

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

The Bureau of Truth controls the “Pou-du-Ciel”. The Ministry will make its decision. The book currently serves them as a basis. If you have not followed my instructions strictly, you may be refused

*the right 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: *iè* no knots, grain about right, *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, 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 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 give him the right 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.*

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,

by economy and sportsmanship, to build their machines themselves. Apparent simplicity. Who could have doubted *à priori*, 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.

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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 Sport de l'Air!*

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 Sport de l'Air!*

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 Sport de l'Air!

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## 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×100cm, thickness 3mm (30 tenths)

7 panels 200cm×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<sup>2</sup> standard fabric

20L standard dope

If you can afford it, get 40m<sup>2</sup> fabric and 30L dope.

#### 4. Wheels

A good size is  $450 \times 100$ .

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  $13 \times 16$

4m  $16 \times 18$

2m  $16 \times 20$

2m  $17 \times 20$   
2m  $21 \times 24$   
50cm  $24 \times 27$   
1m 20cm  $31 \times 35$   
1m 20cm  $36 \times 40$   
20cm  $40 \times 44$

Also, at your option, the drawbar: 1m 80cm  $31 \times 35$ .

Mild steel plate:

$30 \times 80$ , 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  $5 \times 40$

30  $5 \times 60$

20  $6 \times 40$

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<sup>2</sup> 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×0.60×1mm 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 × 50 × 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

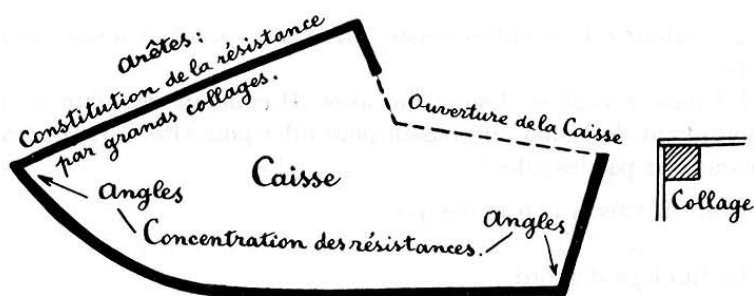


Figure 3.1: The members concentrate the strength of the plywood

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 plywood by 3mm. 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)*

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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  $20 \times 20, 2700^1$  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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<sup>1</sup>Both here and in the figure M. Mignet mistakes himself and writes 2800; the measurement in fig. 3.3 is incorrect.

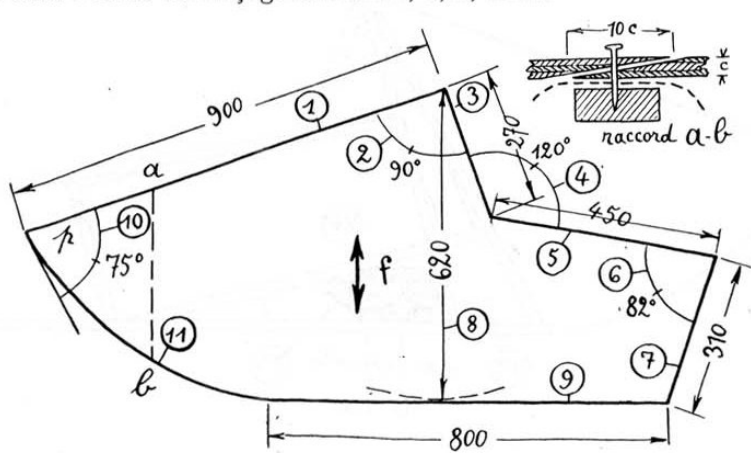


Figure 3.2: Outline of fuselage side

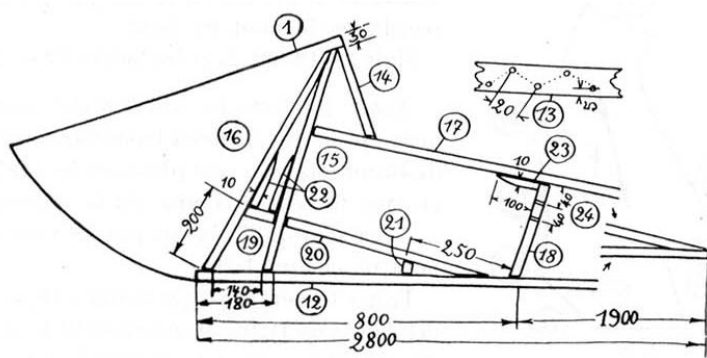


Figure 3.3: Layout of longerons and members, fuselage side

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  $20 \times 20$  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 the gap 26 which measures  $20 \times 60$ . 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.

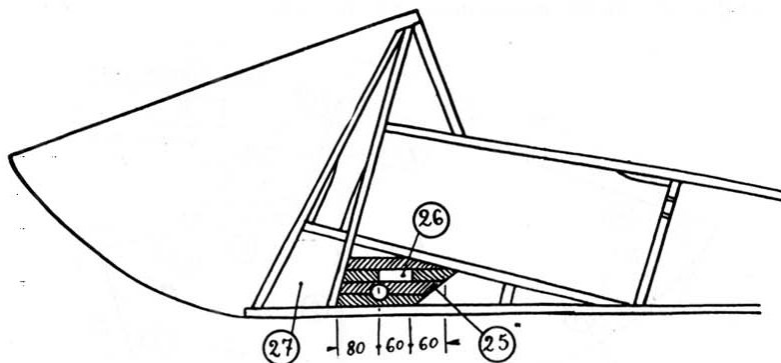


Figure 3.4: Openings at bottom of cockpit

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

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  $5 \times 60$  threaded rod will further secure the flanges (33) of  $20 \times 20$ , 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

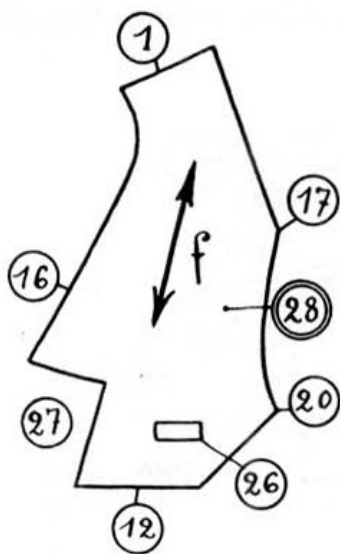


Figure 3.5: Plate inside front of cockpit

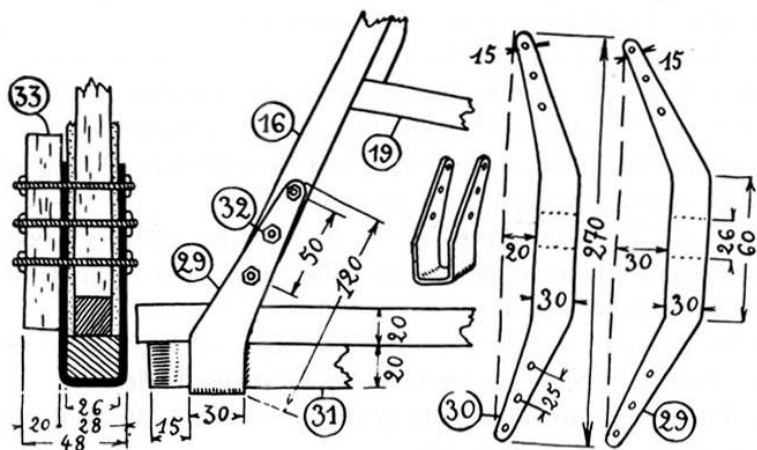


Figure 3.6: Landing gear reinforcement

bungee cord that secures the axle from slipping.

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  $20 \times 20$  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.



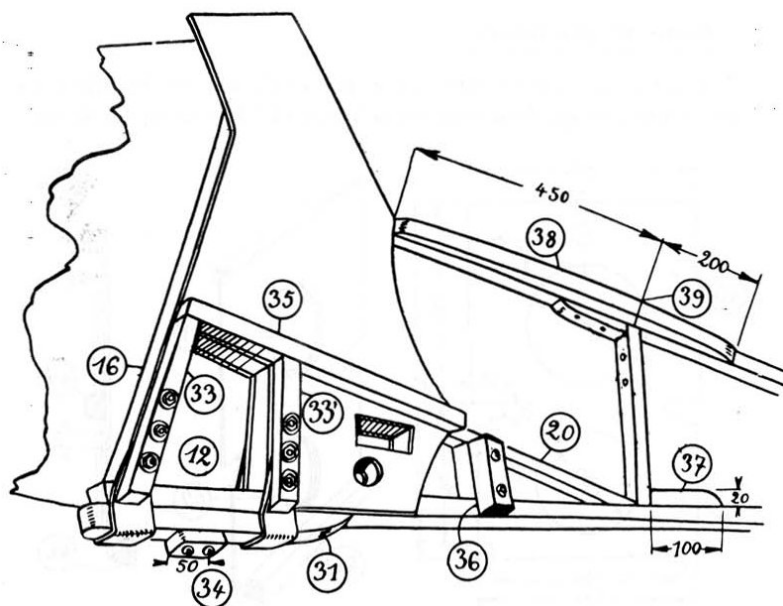


Figure 3.7: The completed assembly around the axle

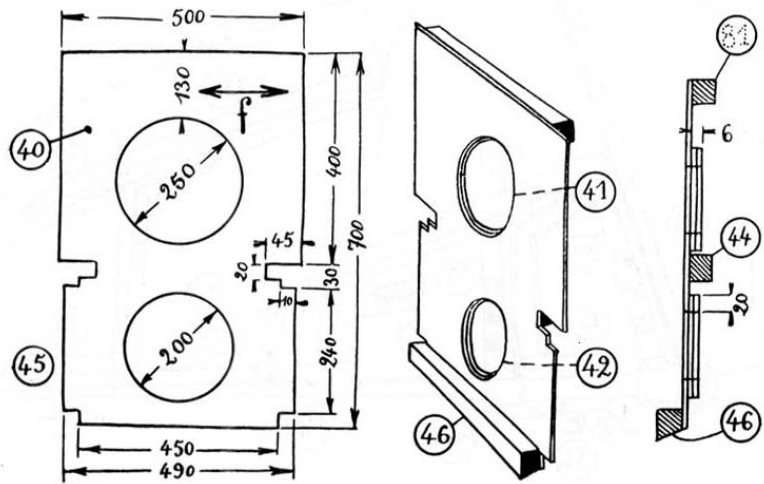


Figure 3.8: Pilot's seat back

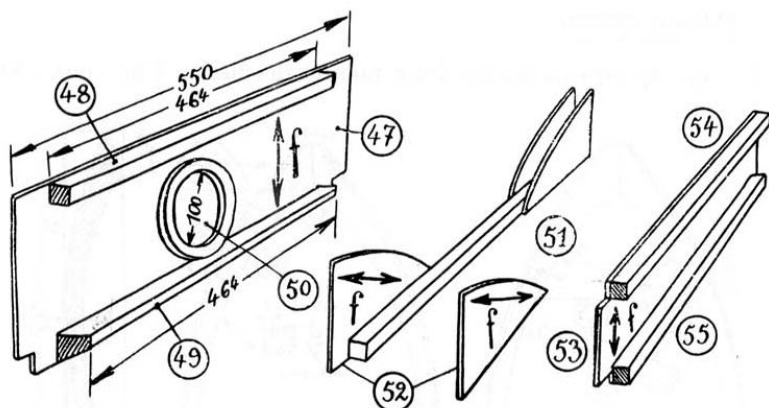


Figure 3.9: Front panel joining sides

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

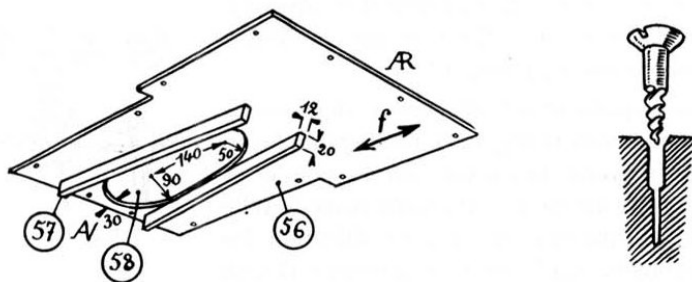


Figure 3.10: Seat bottom from below

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 by  $12 \times 15$ mm 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.

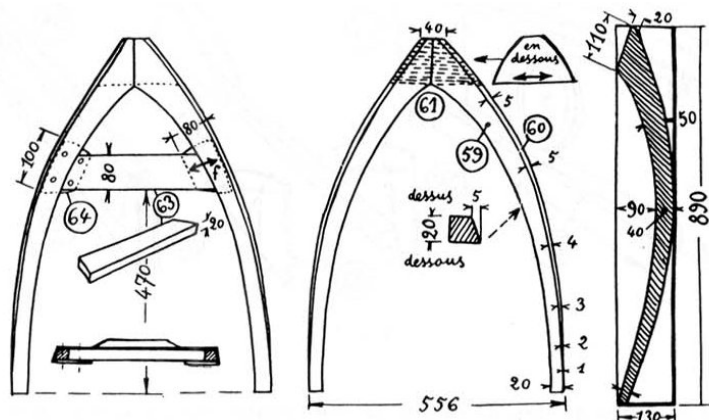


Figure 3.11: The “lyre”

### 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 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

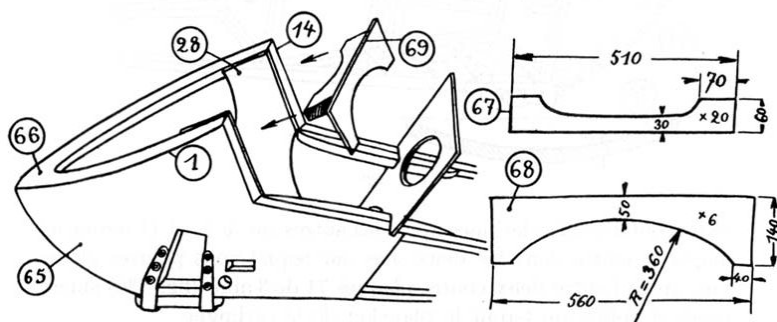


Figure 3.12: Fastening the “lyre” in place

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 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).

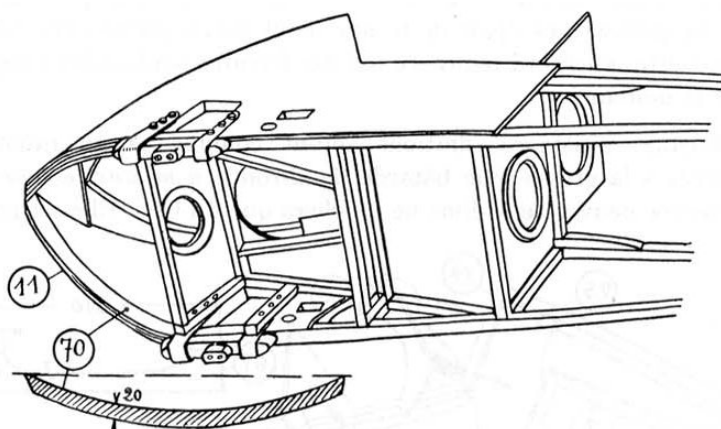


Figure 3.13: Flanges to support cabin floor

### 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.

The floor is supported by a cross-member (72),  $10 \times 20 \times 504$ , fastened in front of panel (47).

With the file, align the lower faces of the flanges (70), so a 3mm plywood piece like a curved triangle will have good contact everywhere from the point to the cross-member (72).

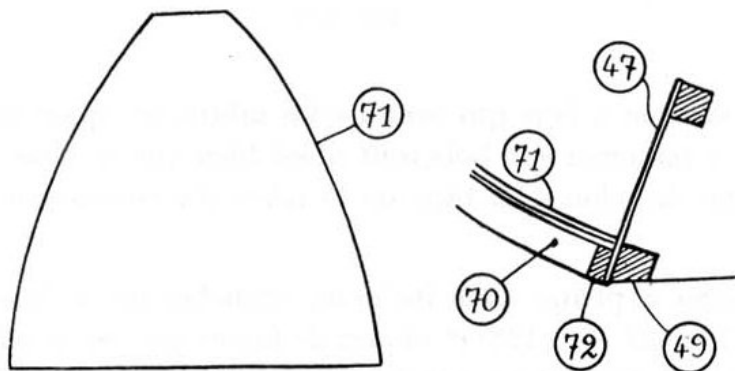


Figure 3.14: Fitting the cabin floor

This forms part of the bottom skin of the fuselage.

Now cover the lyre back to panel (68) with 3mm plywood.

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

### 3.1.5 Rear point

Join longerons (12) and (17) in a point (*fig. 3.16*) with a wood screw (73)  $4 \times 40$  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  $2 \times 40$  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



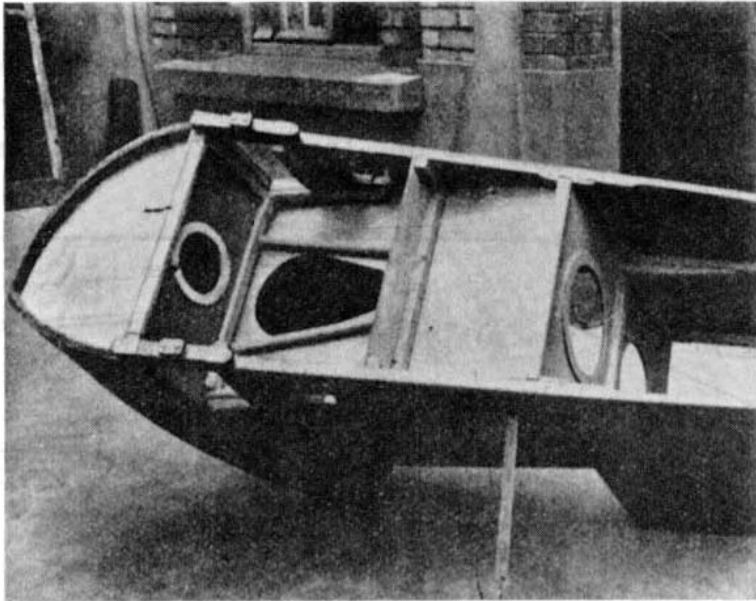
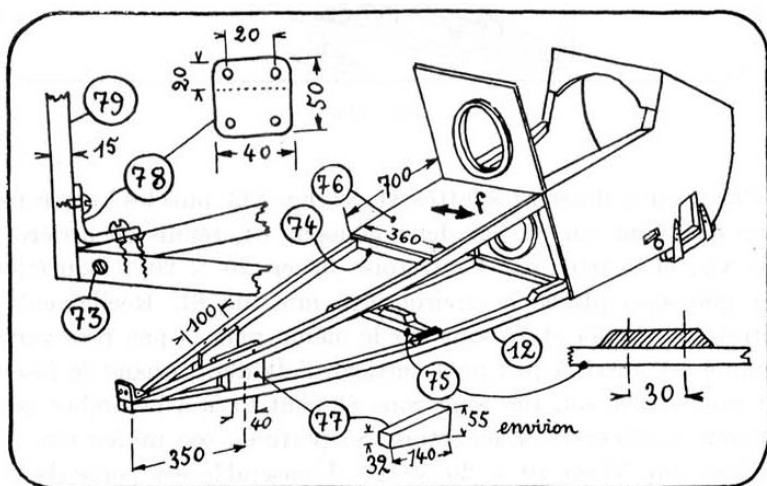


Figure 3.15: The underside of a fuselage before applying the bottom skin in front



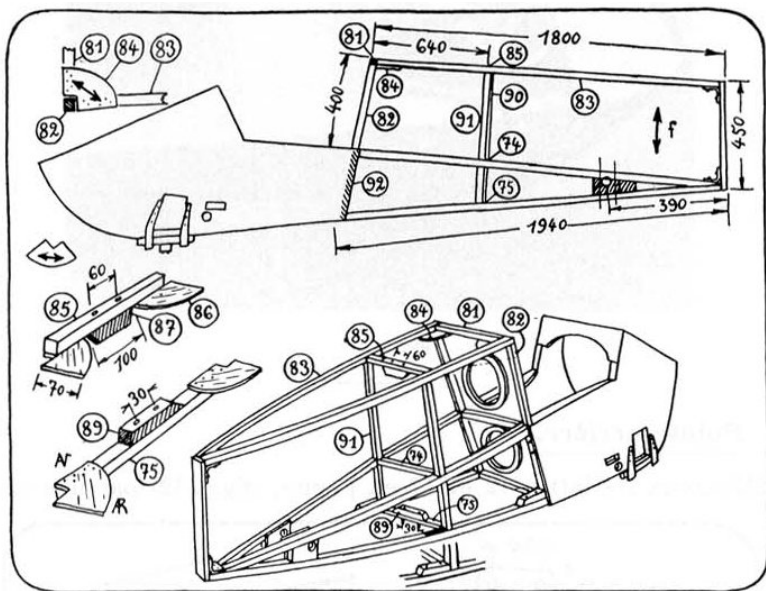


Figure 3.17: Fuselage superstructure

angles. One will be used to attach the hardwood tailpost (79),  $15 \times 40 \times 450$ , to the rear point, using  $4 \times 15$  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 al-

most 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  $30\text{mm}^2$  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.

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.

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<sup>2</sup>The text says 60mm, the diagram shows 30mm in two places; the text is probably in error.

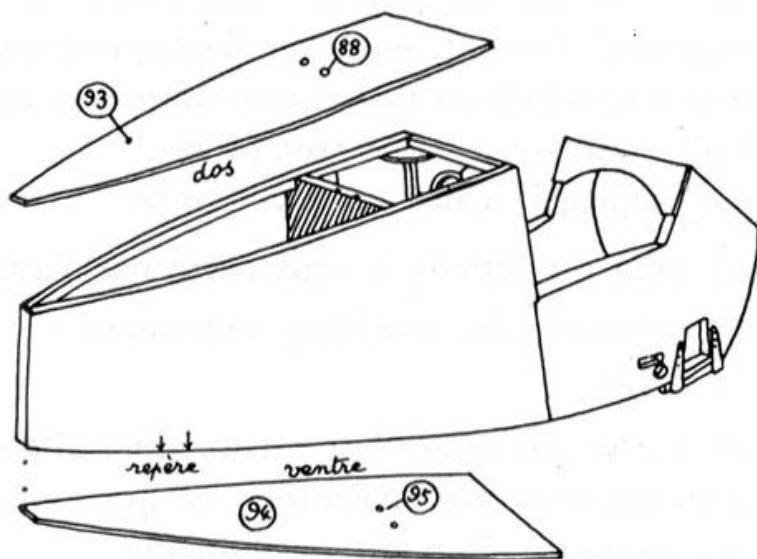


Figure 3.18: Fitting the rear skins

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.

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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 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.

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### 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 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

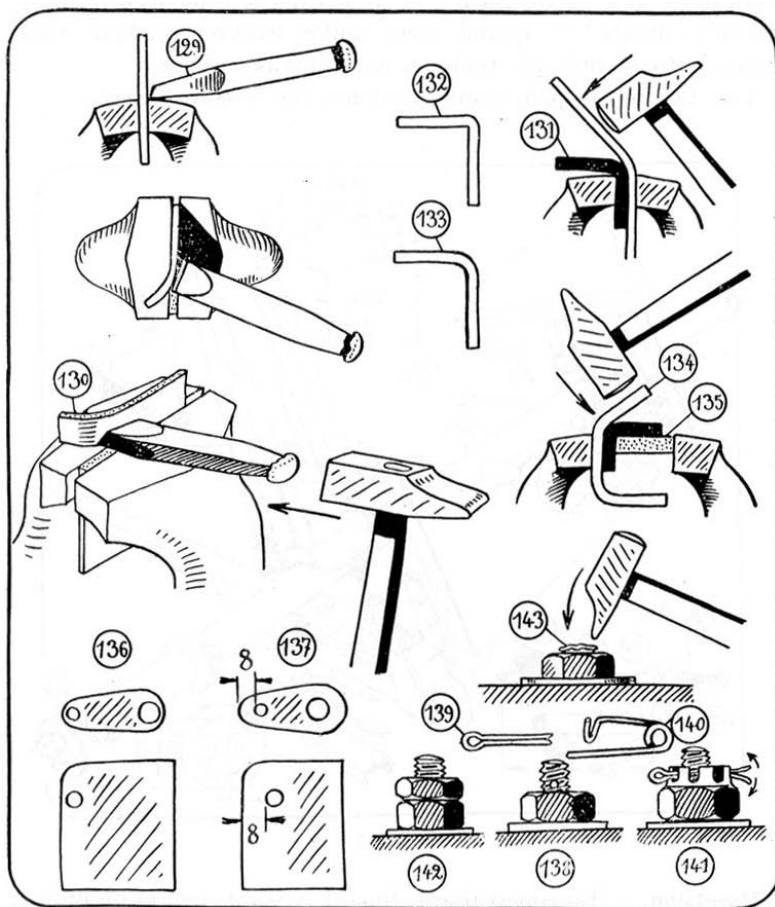


Figure 3.20: Fashioning sheet steel fittings

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  $36 \times 40$  tube (144) (fig. 3.21) 1200mm long, filled with another reinforcing tube,  $31 \times 35$  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

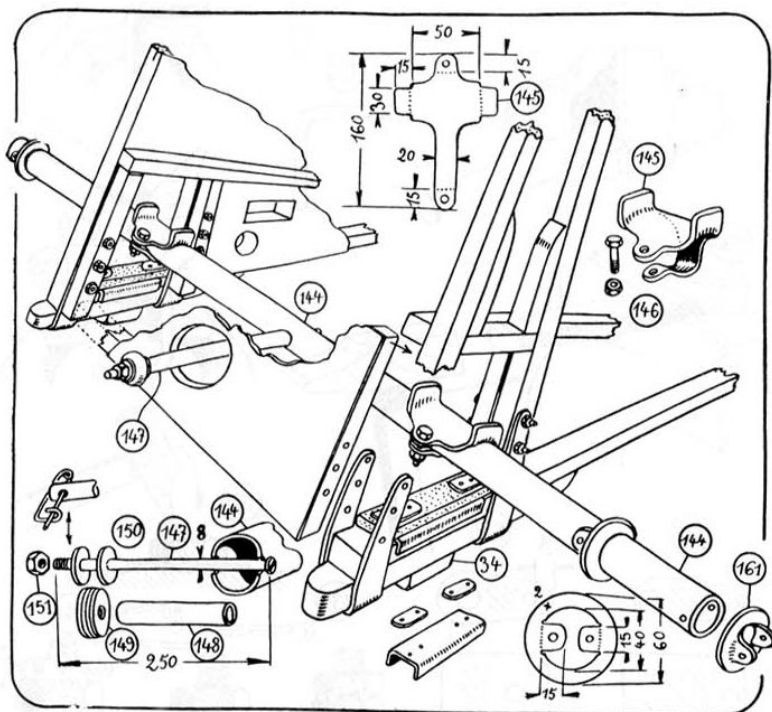


Figure 3.21: The axle and its placement

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 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  $4 \times 20$  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

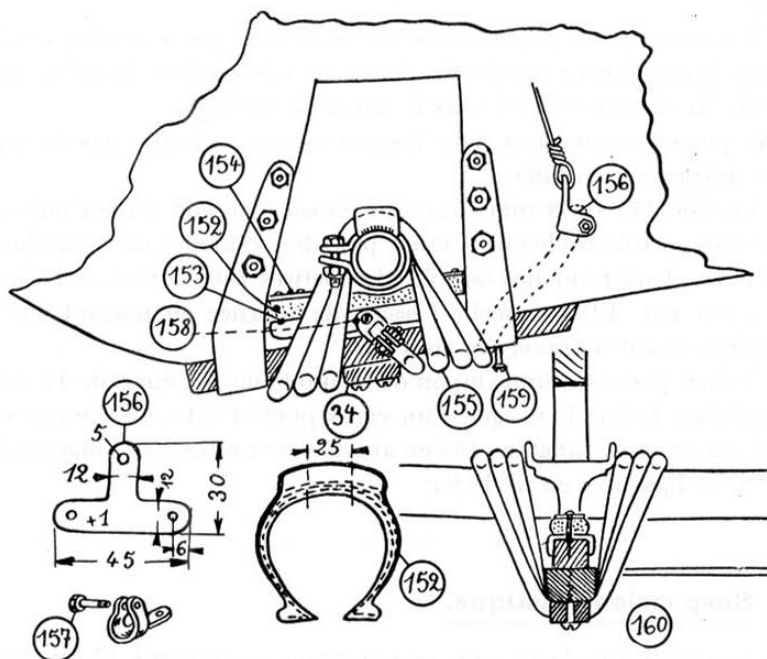


Figure 3.22: Rubber pads and bungee cord

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)<sup>3</sup>. 15mm long 40 × 44 tube ends would 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.

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<sup>3</sup>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.



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. 51*<sup>4</sup>). 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.

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<sup>4</sup>This figure does not contain any such hole.

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 (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

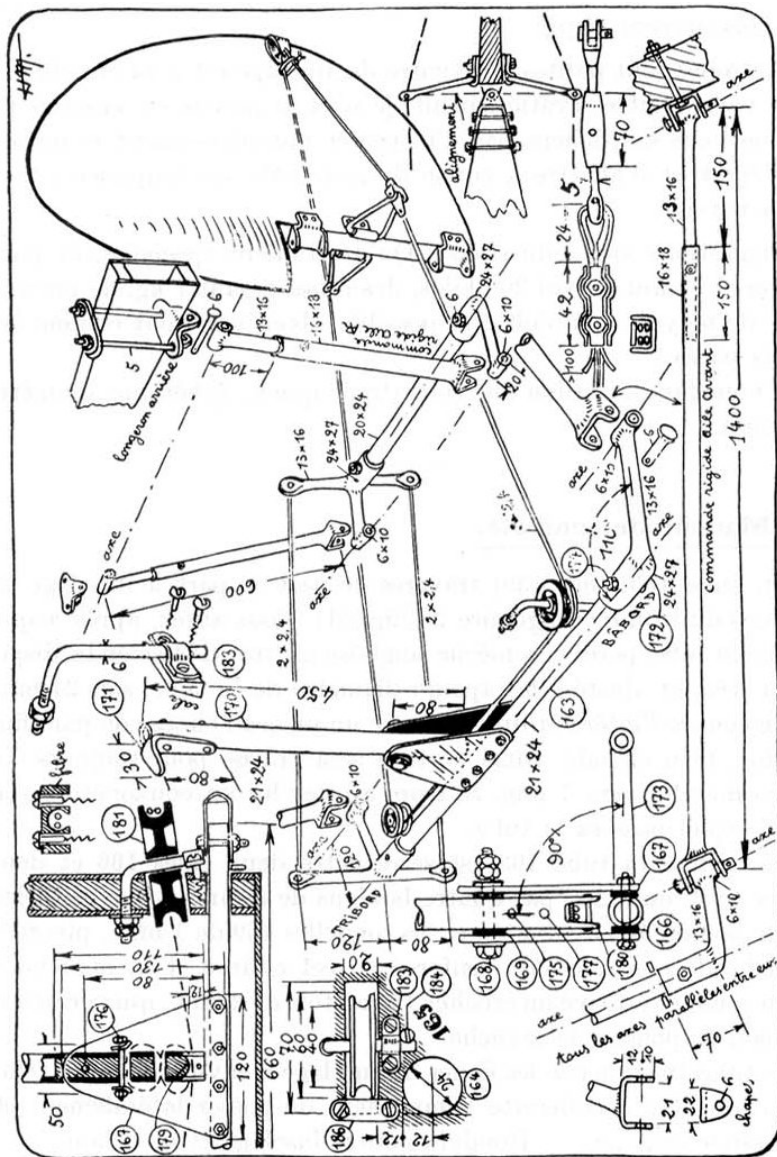


Figure 3.23: Layout of control system

nut inside the fuselage on one end, a bracket (183) on the other, and a  $5 \times 25$  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. ??) 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<sup>5</sup>.

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

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<sup>5</sup>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.

small spar of the rear wing.

Time: 2 days. Weight: 2.3kg.

### 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  $17 \times 20$  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 welding 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.

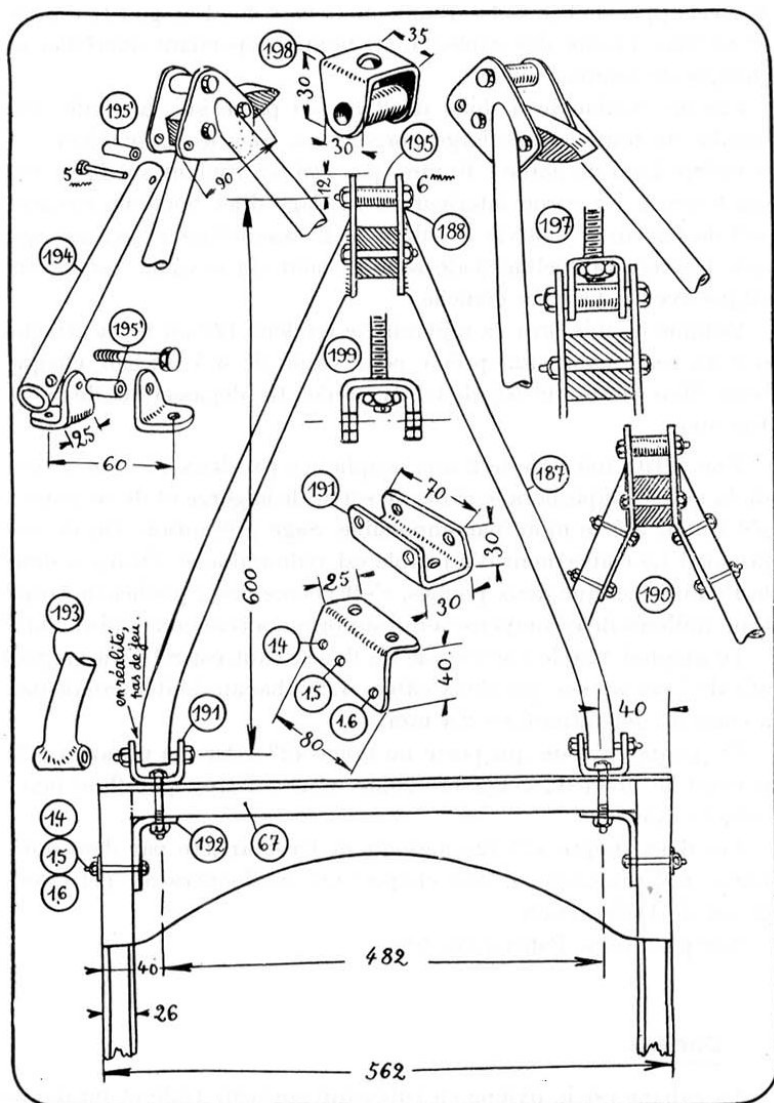


Figure 3.24: Layout of cabane struts





## 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  $4\times 3\text{m}$  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).

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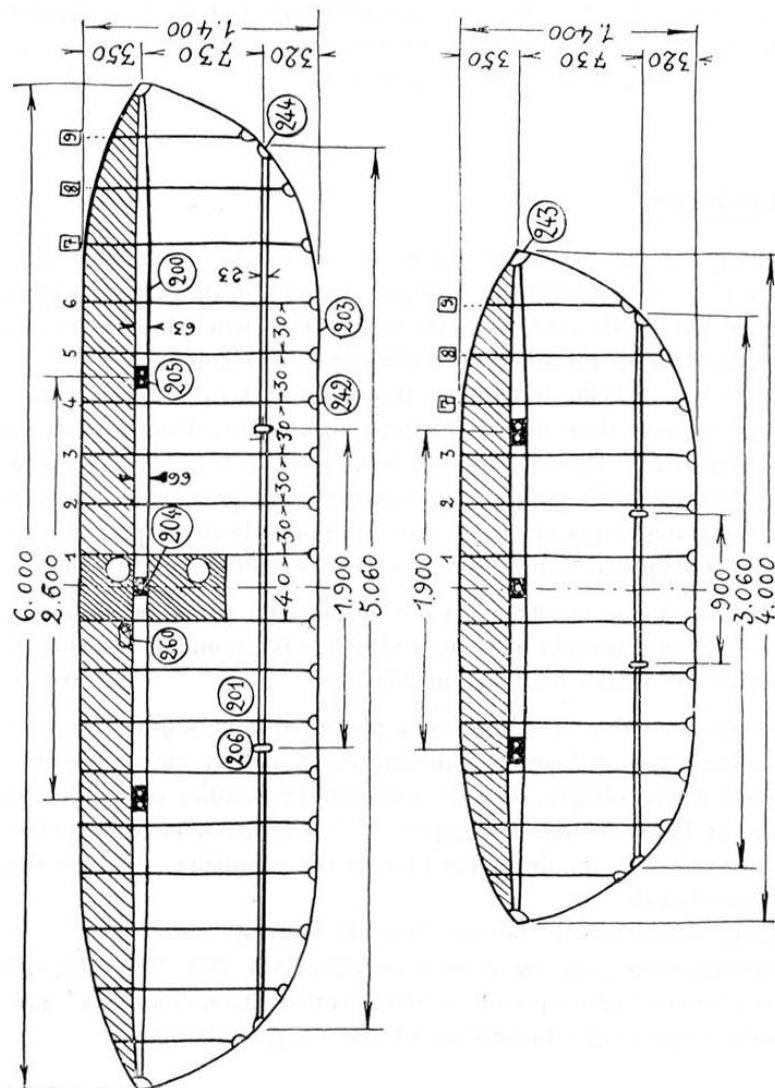


Figure 4.1: Overview of wing structure

### 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.

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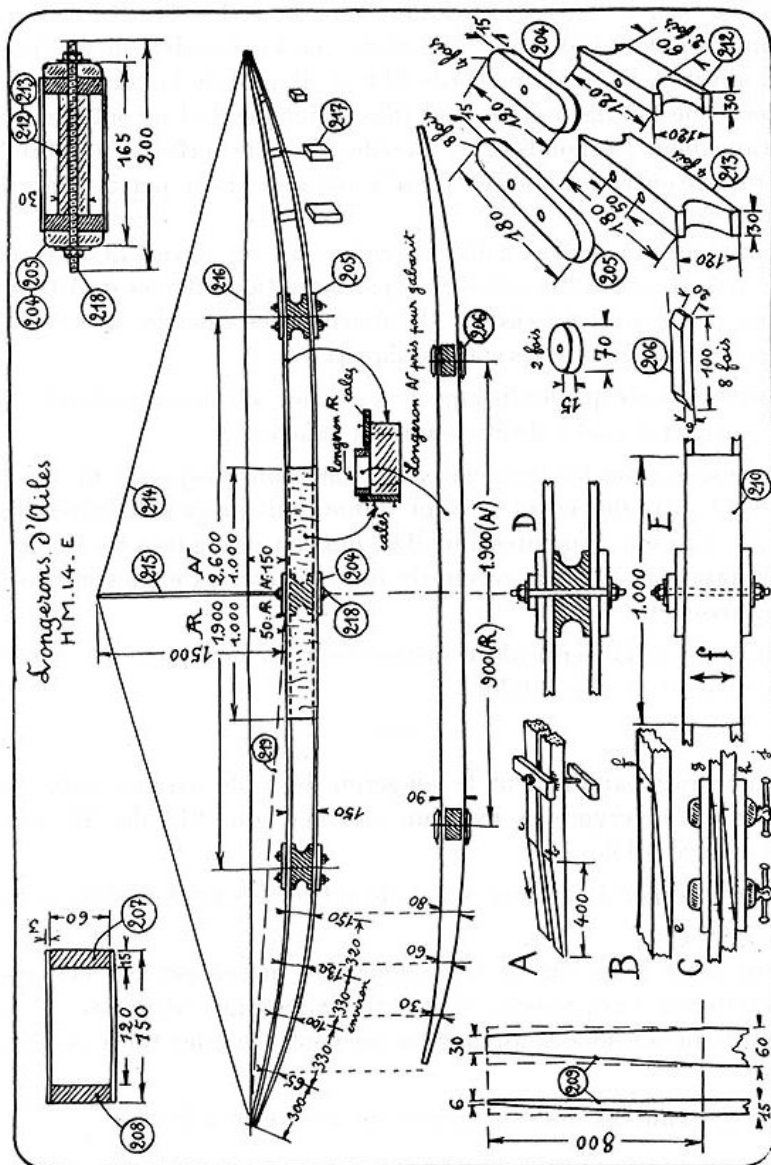


Figure 4.2: The spars

### 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 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.

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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 wing 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!** **Ha! Ha!!**

#### **4.5.1 Ribs**

Cover a board  $300 \times 1500$  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 and is cut from a 12mm-thick board.

350mm back from the leading edge, mark a line (224)<sup>1</sup>: it is 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.

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<sup>1</sup>Which is not numbered on the diagram but can be identified by its description.

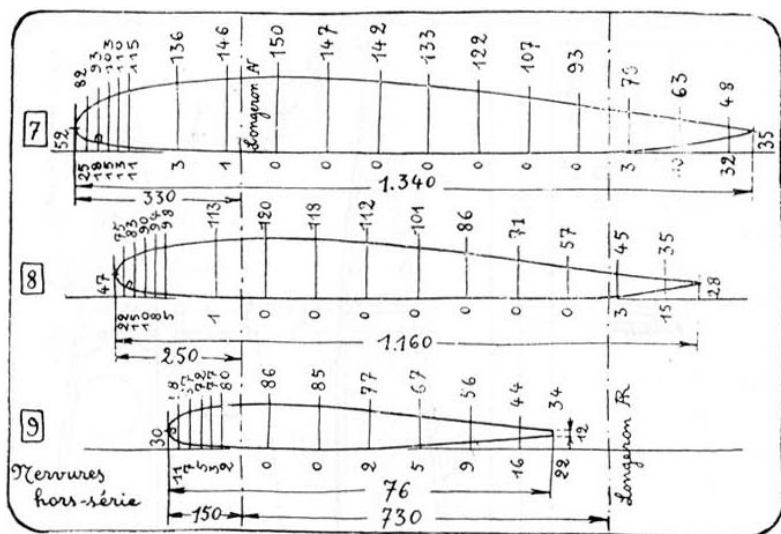


Figure 4.4: Non-standard rib pattern

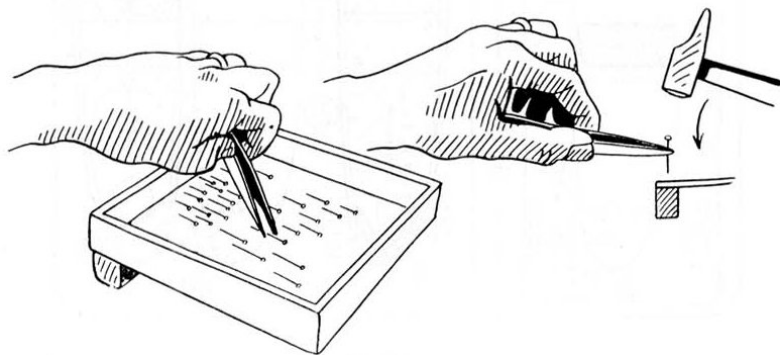


Figure 4.5: Using a tilted nailbox and tweezers

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<sup>2</sup> 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. 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.

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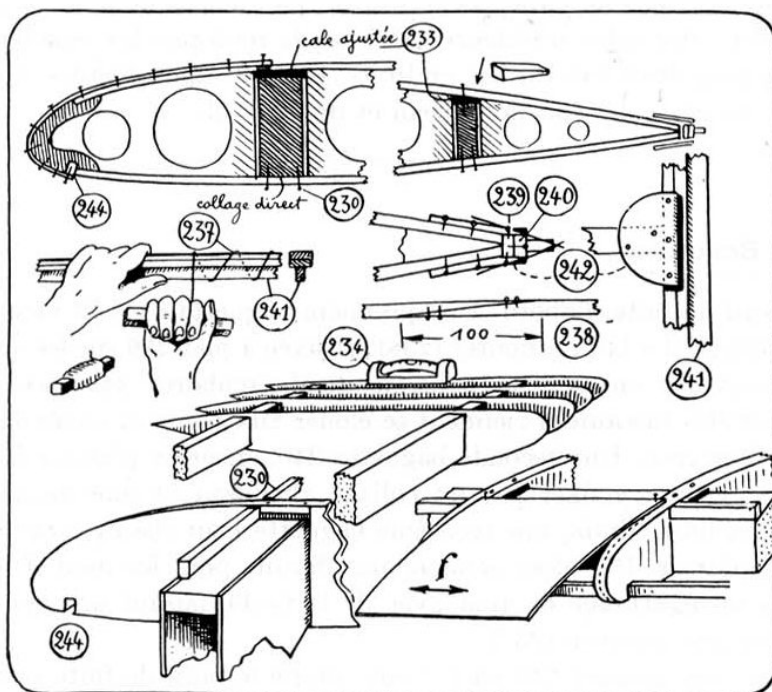


Figure 4.6: Assembling the wings

## 4.7 Leading and trailing edge

Trailing edge first. Take a first strip of wood  $6 \times 12$ , 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  $6 \times 12$  strip is laid from end to end in the notches (244) cut under the nose of each rib. Pieces of  $6 \times 12$  strip are then placed on edge (230). This refers to (230) at the bottom of Figure 4.6, not the one at the top. 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 overlappint slightly beveled edges. This covering



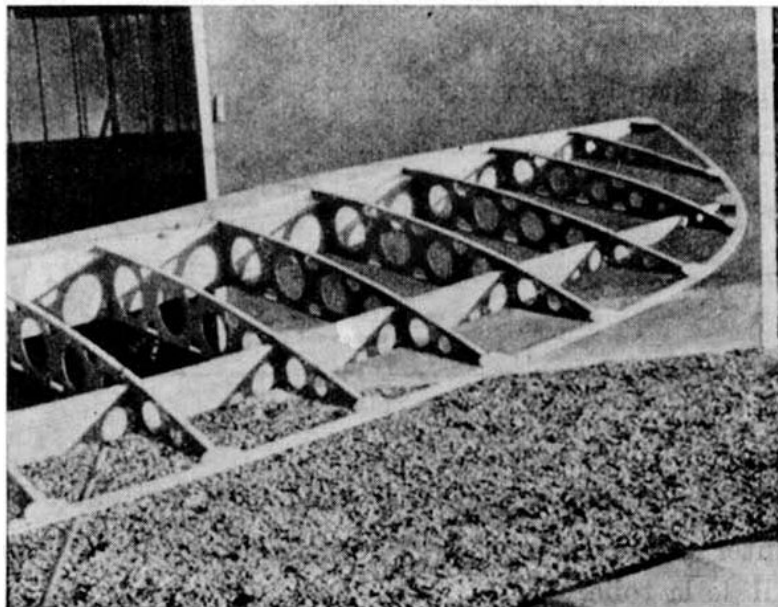


Figure 4.7: The finished wing structure

must be very firmly bonded, so we advise against covering three or four bays with a single sheet of plywood. If 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.

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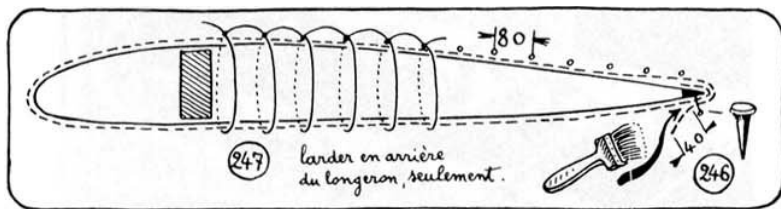


Figure 4.8: Covering the wing

The fuel and oil tanks are placed in the forward wing, between the center two ribs, a 15L one in front of the 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<sup>2</sup> holds it upright and simultaneously holds the nailbox for you. Climb on a 200mm stepstool and stand on the opposite side from the nailing<sup>3</sup>.

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.

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<sup>2</sup>Or a stand — Translator

<sup>3</sup>Maybe M. Mignet means, *get right across from your work*, as suggested by P. Pontois. — Translator

The wing is now bagged like a mattress, so we'll stitch it up like one. Stitch (247) along each rib with good hemp 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 char. 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, 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).

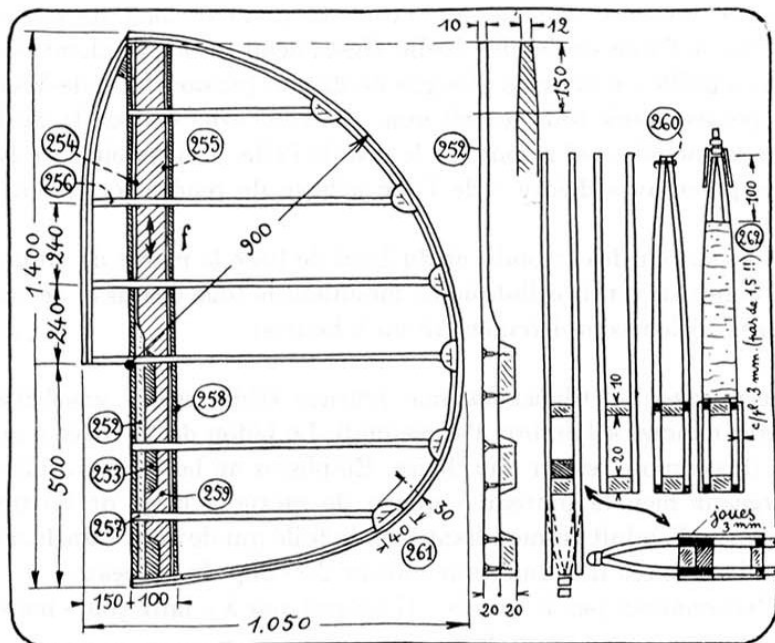


Figure 4.9: The rudder

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.

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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.

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The airframe is finished. What remains is the fitting of the engine, without which, like a face without eyes or a body without a soul, it would be good for nothing.