

HM 14 The Story

AVIATION FOR THE AMATEUR

**THE FLYING FLEA
("Le Pou-du-Ciel")**

HOW TO BUILD AND FLY IT

Henri Mignet

Translated by
THE AIR LEAGUE OF THE BRITISH EMPIRE

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PREFACE

It is with much pleasure that I present to readers who prefer the English tongue a translation of *Le Sport de L' Air*, by Henri Mignet. M. Mignet is a remarkable man. He professes that he is no pilot; he denies that he is a trained engineer; he has not been endowed with an abundance of money. And yet he has allowed none of these obstacles to balk him of his determination to find an outlet for his enthusiasm for aviation.

As an amateur designer he has built many kinds of plane, and many young men have followed in his foot steps in the past. Dissatisfied with the difficulties of flight he went back to first principles and produced at last a design which is, he claims, robust, simple to build, and safe to fly, and four hundred copies of his machine are being built in France at the moment that I write.

But Mignet has done more than this. He has captivated a youthful generation; he has fired them with his own enthusiasm, and he has proved that the romance and the spirit which inspired the early pioneers of flight are still with us, only waiting for some such outlet as he has provided.

In his book he describes in vivid and arresting language his experiences, his ideas, and the details of his machine... I can only hope that in this translation which the Air League of the British Empire has made, the spirit of the Author will live and that very many young men who speak our language will be encouraged to follow him in this new and exciting Sport of the Air.

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PREFACE FOR SECOND EDITION

It is less than a month since a first edition of 6,000 copies was put on sale, and I am asked to write a note for the second edition. What can I say? Mignet's summer tour in England has convinced the skeptics that the Flea does fly; I know that the amateur, following the directions in the book, can build a Flying Flea as good as that flown by Mignet himself. But you must learn to fly like Mignet, slowly and patiently. The machine cannot be learned in an hour or a day; a week or a month must be spent in your apprenticeship, in no wind.

I repeat that we will be glad to help you, but send a stamp for the reply. And if you are grateful for Mignet and his book you might consider joining the Air League, which is proud to have introduced him and it to you.

J. A. CHAMIER.

INTRODUCTION

One ambition has been my driving force during these last few years to spread abroad to a friendly audience the results obtained in following out my ideal, *The Practice of Aviation*.

In 1928, following my experiments, in which I was beginning to obtain a few real results, I decided to sound public opinion in order to gauge the volume of an interest that I suspected, in a confused way, must spread.

I wrote a few articles in the papers, and then a book in which I explained how, with only small financial means, and but a little knowledge, I had with my own hands built my small plane.

This book, in a determined amateur way, I produced myself. Each page was written and drawn by my pen, and then photographed. These negatives, assembled on boards in a certain order, I reproduced on zinc by the lithographic process of "offset." A friendly editor loaned the printing machine and the sheets were finally bound in a colored cover of my own design.

Incredulously my friends saw a small trial edition appear in this way. "It won't sell," they said. "To build an aeroplane oneself, without special tools, without experience; it is not possible. Even if something resembling an aeroplane were made, who would risk themselves in it?" Well, what happened?

This edition vanished in eight days. A second edition, quite large this time, was sold out in a year, without other publicity than a small notice renewed from time to time in a single periodical. After three years, although the last copy has been gone some time, I am still receiving orders for it.

The movement has started. The great family is everywhere. I feel myself carried on the strong shoulders of a multitude of friends.

The results obtained, the evolution of the movement, the progress made following trials in the air, the correspondence from my readers (which keeps me fully occupied) guarantee that from all this something must come. Thus, I have been working on the material for a new edition for three years.

The volume is substantial. The old arrangement, the work of an amateur will no longer do. This time it's a book a real book which is needed, presented in accordance with the resources of modern printing. Will it cost more? It doesn't matter. I am not a paper merchant. In order to be read, I must keep within the reach of the average reader, guided by, the very stout conviction that something must come of it.

The theme is large. It takes many words to evolve ideas. I admit humbly that I have only a clumsy vocabulary, where the "whichs," the "whos," the "hows," and the "because" lead the reader a dance to the detriment of clearness of style. What would you? my eloquence is of the common type and my pen runs its little course. These few years of solitary camping have not helped to give it grace and distinction. If you follow me to the end you will manage to understand me all right. I ask for no more.

I only wish to have your confidence. Believe what I am saying. This book is not a love romance of a naughty little girl. It is real. It has been lived. It has been suffered. You will have no need of queries. I have dotted the "I" of all which concerns myself, and my reputation may suffer. I will be accused of a swollen head but I have got it off my chest.

The first book held between its lines some immature ideas: since then these have become realities. It is no longer necessary to guess my deepest intentions; you can read them word by word. To day I say all that I think and I give the details of what is to be built. I shall limit myself to one single type of machine. It is no longer the moment to try things out and to experiment indefinitely. I have had the trouble. The fruits must be gathered, but they must be ripe fruits.

Since it is necessary that the amateur should fly without difficulty, should fly without danger, I must give him precise instructions.

Readers, my correspondents, there are many of you who are of my way of thinking, you have allowed me to measure your enthusiasm. You have demanded this book of me. Here it is.

The Flying Flea, No. 4, begun on the 6th August, 1933, took off from the ground on the 6th September. After three months of adjustment in the open, it came back to the workshop in good order after ten hours flight; not ten hours of cruising in calm weather under a blue sky, but ten hours of difficult trials, ten hours of flight in midwinter, in bad weather, in rain and in storm. Ugly clouds have scudded under its wheels. Fatigue and excessive cold gave me hallucinations in flight. The Flea brought me back. A short life, but a life spent in hard exercises. A proved formula.

What have I to fear? The failure of my campaign? Oh, well, I can't help it; it has got out of hand. it is no longer I, Mignet, who speaks, it is a force which swells, of which I am but an echo, and which is everywhere. And I proclaim this force since nobody makes:

a move, since others better instructed than I, and more qualified in science, in the art of the air, sleep in a stagnation which they call the "crisis and which I name "blindness."

Build, my friends. Go right ahead. The question, has never been presented; let's present it; it will insist on a solution. This solution will certainly come, because it interests not only our amateurish hobbies but the actual progress of human science. No man of law, no ministerial paper scribbler, no policeman can stand up against the laws of progress

Long Live the Sport of the Air.

I go right ahead and listen to no one. Will my idea succeed? How many people will think me a mad man? How many, also, will be with me? I know.

All the worse for the former, all the better for the latter. Whatever happens, what will happen is of the greatest interest.

Oh, how beautiful is our Aviation!

The Flying Flea has passed its tests. The perfect formula? Far from it. It can certainly be improved upon. I leave it to amateurs to alter its details, to improve its flying qualities. I have brought out the model. As it stands, it's quite good enough.

To aim at perfection would have prolonged my game of promising publication of my book from quarter to quarter . . . that has been going on for many years. . . . I hardly dare believe that I have reached the last month.

To bring out an original model, even a simple thing like this, is not done as easily " one paints a theatrical scene or improvises an illusion on the cinema screen. I am pleased this is now in the past to certify that everything set down here has been tried out, has been lived, has been felt, has been thought out, has passed through the sieve of trials, which have been at times very severe. The isolation, the living in camp the heat, the cold, the lack of funds, alas . . . the boiled potatoes and the

rice cooked in water. . . . I had to stick to my road since at the end of it was the Flea. Without false shame I admit it. What does it matter to me? All that is in the past. Ahead of us life is cheerful: the machine is small but good..." It does fly."

In my book I put all my confidence, all my faith. It is the expression of a candid man, of a wild man who is aghast at the useless rush of the century, but who loves aviation, as he loves his children, as he loves his wife, with all his heart and soul.

THE FLYING FLEA

CHAPTER I

THE SPELL OF THE AIR

Why can one not, once one has been near it, free oneself from the influence of Aviation? It is a new era which has come to us. Is there a new air record? or an air catastrophe? The papers are full of flaring headlines and a dispatch of a few lines is expanded to columns of print.

Why is this? Is it the work of journalists short of copy? Certainly not! It is done to satisfy the worldwide interest in air matters. It is not unhealthy curiosity, it is the response of our inner beings, an instinct old as man.

THE ATTRACTION OF ADVENTURE

We pursue adventure on the roads through the lure of speed. But the roads are no longer roads to romance but carry a glut of vehicles past signposts and policemen. We fret because we cannot pass a lorry; we return at night blinded by other motorists and terrified of hitting a cyclist. Any adventure we may have lead to the police courts! I have no use for the road.

But the air! there we have it! Speed, the sense of being a navigator and an explorer, the freedom of wide spaces, adventure aviation puts all of them at our disposal.

Everyone who has flown is bitten: everyone wants to fly again. .
A flying magazine comes each week, to the house, and is devoured from cover to cover. Names of pilots, constructors and machines become familiar; monoplanes, biplanes and record breakers take recognizable shape; every aeroplane which passes overhead increases the desire.

To fly! to live as airmen live! Like them to ride the skyways from horizon to horizon, across rivers and forests! To free oneself from the petty disputes of everyday life, to be active, to feel the blood renewed in one's veins ah! that is life.

There is one great satisfaction which the sport of aviation can bring and that is the speed with which one can become versed in it. One does not need, years of study, an engineer's tools, or a life of calculations and figures. Alone among vehicles the aeroplane may be built by the amateurs few directions, some patience, a little money, and in two months your machine is flying.

One may, have a feeling for a motor cycle: a car is no longer a thing for which one has affection. An aeroplane, self built! that is something which one loves! You do not love a thing you buy!

LIFE

Before me is a sleeping mechanism which in a moment leaps into life as the engine starts. The machine moves forward; the tufts of grass pass quicker and quicker until they merge into long blurred lines. Suddenly something happens! Like a car passing from a rough road to smooth macadam the machine becomes steadier and hardly touches the earth! We pull gently on the stick and the ground falls away a map in green, height without sense of giddiness.

The speed? What does it matter? The sensation is unforgettable; it is the recompense of all my efforts; the dreams have come true.

I have flown in an aeroplane made by myself.

On my aeroplane!

Is aviation merely a matter of bounds and of aeroplane trials? I know full that it is always taking me further afield. The air road leads to everywhere. Ten miles or 1000 miles, what does it matter?

My machine need not be envious of others: it is a real flying machine. I dream of magnificent fights. .

After a little practice perhaps I can fly across a continent And why not?

An aeroplane passes overhead. You wave to it. Do you think that the pilot sees you or laughs at the chickens which scatter over the yard? No, he is looking at his map; he is busy flying. A storm is coming up and he sees to it that his safety belt is tightened.

Aviation seen from the ground is quite a different thing what it appears in the air. Height has little meaning. You seem high at 50 feet; really high at 500; at 5,000 you seem no higher. Your air, road seems to be glued to earth! A moment later a change takes place! The wind freshens. The horizon becomes less defined. There are shadows below. A mountain barrier rears itself before us a barrier of clouds.

Our airway no longer seems glued to the earth: there is only emptiness beneath our wheels. The sea of clouds flows past underneath us, fleecy, in vague forms, in high and twisted peaks, which the shadow of our little machine, outlined by a circular rainbow, seems to caress as it passes. What marvelous glaciers! What gulfs! A vision of Dante, a prehistoric's world boiling as it takes form!

The cloud masses get heavier. One can no longer see the earth. Above we have a quiet, unclouded sky; below nothing but cotton wool. The whiteness is startling; the light is overstrong.

We fly on for ten minutes, with no change. The world is a desert and we are alone. If the clouds or fog reach to the ground we cannot land without accident. It will be wise to turn and retrace our course; in ten minutes we shall be clear again. The wing banks over in the turn a flock of wild duck passes below us. We watch our instruments and wait, while we listen to the engine.

You, the driver of a car, do you know your engine? Have you felt it? Has it ever saved your life? My engine sings its song. I listen to its cheer note. I care for nothing else. How it pulls! It does not want to lose me! My machine is no longer something which has been made and sold, something which has been nailed, and glued, and planed. The Man and the Thing have become one, a single whole; the wings are animated by the hand.

My kind of private aeroplane is not an instrument for business: I do not know if it will ever be that. There is much that is unexpected in its life: the man is not completely master of the machine.

With all one's care something unforeseen may happen a drop of water in a jet, a magneto which ceases to fire.

You have a machine carefully engineered and fully air worthy. A little bit of grit for all your care passes into the carburetor. A dozen times it threatens to block the jet while you, unheeding and happy, watch the bathers on the beach as you fly low over the sea.

Your forced landing awaits you! "Then it comes it will not be over those nice large fields but over some forest or vineyard. The engine is slowing ! . . . You begin to lose height! You hope it will carry you to the next open space, but all of a sudden it stops! You must make up your mind quickly what to do.

That is another adventure in your life.

The man is not sure of his machine, he has still less certainty of the weather. Today the weather is grand. At nightfall you spread out your charts trace courses, calculate times. "I shall take off at 8 o'clock."

You take off with a fair prospect before you, thinking over all the route you will follow, where you will eat and drink, the friends you will see and your return in the evening.

Don't be too confident! You may meet rain or storms or fog. You may not be able to go on, or you may fight your way through bumps, against a head wind, in gathering darkness, with fuel running low until you get to the end of your journey. A little tired, a little cold, you have still to make a good landing! With a sign of relief you come to rest and loosen your safety belt. To night you may wonder if it is all worth while, tomorrow you will come, keen and fresh, to live the same life again.

The air is an ocean where things; happen unseen. The squall which is visible on the sea hits you unexpectedly in the air. A hilly region may be impassable for your small machine, or even a larger one, in a storm: in fair weather it may be marvelous. But it is not always fair weather.

No! the aeroplane is not an instrument of business it is a pleasure vehicle.

A PROFESSIONAL CHANGE

My daily life is changed. I see everything from another angle. A draught, a journey, an engine starting, a bee buzzing against a pane... all these remind me of my aviation.

Life is finer and simpler. My will is freer. I appreciate everything more, sunlight and shade, work, and my friends. The sky is vaster. I breathe deep gulps of the fine, clear air of the heights. I feel myself to have achieved a higher state of physical strength and a clearer brain. I am living in the third dimension!

Is the weather fit for flying today? The thought makes me look up where ordinary mortals look down. I tap the barometer twenty times a day, and harder when it is going down in the hopes that it will go up!

In dirty weather when I cannot go out I love to take out my maps, spread them on the dining table, put weights on tile corners and work out some more aerial voyages. Don't they look pretty with all their little villages and woods? Surely I couldn't lose myself? but I know I am a bad navigator.

Here is a little field between a wood, a marsh, and the railroad; I came down there with a broken petrol tap. Look at that valley! how beautiful it was in the red glow of the setting sun last summer.

When I am walking, motoring, or in the train I look at the country only from one point of view is it good for landing or not! What a fine smooth meadow, a little small perhaps but with good approaches!

An aerodrome is a far finer sight than the bustle of a railway station. The sheds are full of mingled wings; great names, Imperial Airways, Air France, Lufthansa, T.W.A., United, blazen their sides. The sounds of engines come down the sky and echo among the buildings. The doors open for the big long distance machines which travel to the corners of the earth.

THE HAUNTING WINGS

My machine has just been built. Here it is on the ground. My tent is pitched and everything is in order. The wind is too strong for a trial. I am respited!! At 5 o'clock the wind falls. The flags flap lazily. We can make our first trial. Everything is ready. There is no excuse: we must make a start.

What do test pilots think? Their placid faces show no emotion. Perhaps they are accustomed to their job but I am not. Am I skillful enough to try this new machine? How will it control? What will happen?

My machine and I look at one another in silence. I hate these starts in cold blood. . . . I've got "the needle." . . . There is a little heavy feeling at the pit of my stomach. I don't feel very keen this evening!

Well here is this horrible propeller which can break your arm if you slip. . . . I leap at it and the engine springs to life. I climb hastily into the machine. I open up the throttle. I forget all I had to do. I grip the stick and fix my gaze ahead. The ground flows by. The song of the engine ceases; the ground rises, up in front of me. Pull for the love of mike! pull, or you will go over on your nose. Well, how long was that? Ten minutes, no! ten seconds!

Would I give up this torture if I could? No! I love just that! It is my obsession, myself! The thing which compels me to camp in this lost wood, to deprive myself of elementary comforts. This is how I choose to practice Aviation, to test my prototypes.

And after you have taken off ! Oh, the sweet moments when the bumping is over and the flight becomes smooth, when you have time to look around. You become yourself again, you relax! Profit by these moments to enjoy this air sport, to realize that the object of your dreams, which you have so long contemplated on paper, is a living thing which is working, and that it is you, you yourself and nobody else, who is with it at this moment, full of life. . . .

Here is something, which nothing else in the world, motor car, boat or cycle, will ever replace.

And that is the reason why a man, who would never attempt to build a canoe, cycle, car or other vehicle, will set himself to work with unexpected energy on His AEROPLANE!!!

For him the realization will be his pleasure, a relief from his daily life, and he will one day recognize the sublime moment which precedes his first flying trial.

Having lived through such adventures I am ready to repeat them. I look for them; I like to think there is something unexpected which may happen, and that it is not a question of a flying laboratory, without attractions or emotions. That is the reason why I could not live far from my aeroplane, above all, why I should find life horribly empty on earth without ,wings.

The aviator is a new man, transformed by his own child, an artist, a poet who dreams dreams. The power of maneuver in three senses, distant horizons, the green sky of high altitudes, the poetry of empty space, the risk which the adventure holds these are the things which make aviation a vocation, Which serves, as nothing else can serve, human sentiment.

THE SPELL OF THE AIR!

CHAPTER II

WIRELESS AND AVIATION

Every man has in his heart a sleeping power. We all like to use our spare time in repairing our furniture, hanging bells, hammering in nails, papering the walls. We are all, in a word, amateurs.

The wireless amateur is typical. For several years past and the movement has run through the whole world we have been absorbed by a task from which we cannot escape. Under the pretext of distracting us with music a great mass of literature is published about wireless, which is concerned with describing the details of construction, so that the amateur can make first class wireless machines of a very complicated nature..

A man who doesn't know anything about except that he has probably heard it often, and who possesses a few tools, often finds himself falling into the arms of this insidious fairy. Aided with all the drawings and writings with which those who sell wireless parts provide him, he soon has his tables filled to the great annoyance of his lady wife with a crowd of objects, masses of wire, which will become some day his own thing.

Year after year he puts together, and pulls apart, and changes and alters his apparatus; without thinking he spends, little by little, on his hobby perhaps 50 to 60.

The man has been bitten by a microbe; he has become a crazy amateur, and he is really not interested in using his machine; he is always experimenting, and noting and adjusting and stopping, and he maddens those around him, because he only lets them hear short bursts of music.

Amateurs of this type are legion, and there is a large body of people who cultivate this microbe in order to keep the epidemic going, and who have founded a whole industry of great activity. . . .

Can we compare wireless with its twin sister, Aviation? The former has become commonplace, the latter is, at present, unusual. Radio amateurs can be numbered by hundreds of thousands. How many aviation amateurs have we?

Let us say that the amateur wireless constructors",,, has spent some 50 before he has really got a good home made wireless set. You do not need any more than that to build an aeroplane of first class material, in fact if one is a clever thinker, one needs much less.

Here are the expenses in detail of my machine. There are in an aeroplane two essential parts one is the airframe, and the other the engine. It doesn't require much brains to see that when one is talking about aviation, whether it is war or touring machines, or little machines like ours, without an engine you cannot fly. Even gliding requires some sort of motive power to launch the glider, and if you wish to have complete security and a certainty of doing good performances, the engine is the most important part.

The airframe, which is the principal object of our studies, and which takes most of our efforts, is not a great expense. Here is a summary of the prices of new materials in France, without any special discounts:

2 Wheels 280 francs
25 sq. meters of fabric 200
20 liters of dope 140
Laths and strips of wood planed 200

Plywood 150

Oddments of ironmongery 300

A block of wood for the airscrew 30

A total of 1,300 francs. After this expense you will have to spend a little more to put it together, but all in all the airframe is not expensive. You could doubtless undertake it more or less at once. It requires about thirty days of work of eight hours a day to complete the machine, ready for its first flight. There is less hurry about the engine. As it is so expensive, we may have to wait for an opportunity of getting hold of one without impoverishing ourselves. A motor cycle engine of about 500 c.c. is worth about 3,000 francs new, but you can often pick one up which has been overhauled as good as new for 1,000. A good engine, specially designed for light aeroplanes, costs about 3,000 francs without gears, and 4,000 with gearing.

"Well," you will say, "if we are only going to amuse ourselves in the fields with the machine, making short hops, this ordinary reconditioned motorcycle engine will be quite enough." All I can say is that in order to fly quickly, or at least to take off, do not hesitate to spend your 4,000 francs. You will get a very fine job, and after you have spent the money you will forget about it, and you certainly will not regret it.

However, begin by building the airframe. I am sure that you will then start economizing on your domestic expenses in order to save the price of your engine. So much the worse for the cinema and your short drinks. Never mind! your brain will be all the clearer, and your 4,000 francs will be soon accumulated. That is what I did, and I did not regret it.

The sort of tools which you want to build this machine are those which anybody who builds wireless sets will have by him; perhaps some day some shop will sell sets all ready for you. In fact I have no doubt that soon you will see in these big shops a whole lot of aviation material, with an engine enthroned in the middle surrounded by bits and pieces of all sorts and all prices, just like we see in wireless shops.

The blood relationship of these two sisters, wireless and aviation stops here. All the same, there are two kinds of aviation, just as there are two kinds wireless there is the aviation you buy, and the aviation which you make..

Ah! no, an aeroplane is not comparable to wireless apparatus, it is better, it is larger in the true sense of the Word. It is a hobby but not a toy. It does things. The grown man continues to play as if he were still a child. He either tortures materials, or tortures people, according to his temperament, but whether he is in business, or in the Army, or in industry, he is always playing. . . .

It is not necessary to have any technical knowledge to build an aeroplane. You are only the maker, the workman, without whom, of course, the designer would be incomplete. He has prepared the work, you have only to carry it out, following point by point the road which he has indicated in detail for you to follow.

To build an aeroplane comes to this, to glue plywood to strips of white wood, which one joins together with bits of metal and little bolts.

Several yards of steel cable, some bits of bicycle tubing, some fabric sewn with great knots, a lick or two of dope.

If you can nail together a packing case, you can construct an aeroplane.

Here you have your little pal, all bright and new, with which two or three friends can have some very happy and unforgettable hours. Become an active amateur! Come on, construct your aeroplane!

SPORT IN THE OPEN AIR AWAITS YOU.

Don't think that I am exceptional. I am over forty years old, a man of routine, a typical man in the street.

Foolhardy and bold? Not at all. I am giddy at the top of a ladder; I detest riding. I am a family man with children to educate. I have no wish to risk my neck. nor the necks of others.

I deny that I am exceptionally lucky or skillful. It is just because I am like everybody else, just a plain ordinary man that I defend my conception, that I write my book for normal people, that I will launch them, if they will follow me, not into danger but into the finest of sports the sport of one's dreams.

And let me repeat once more

TRUE AMATEUR AVIATION IS NOT A QUESTION OF MONEY.

CHAPTER III

WHY?

WHY I BUILT THE FLYING FLEA

I BUILT the Flying Flea because I have a passion for things of the air; because I cannot live far from wings; because I love to fly this little machine which is both docile and full of life, to live the magnificent sport which is Aviation; because I was inescapably drawn by the poetry of large spaces, of the open air, of the clouds, of the light, of color, in a single word I am under the spell of the air.

But I also built the Flying Flea because there was no other way for me to enjoy the Sport of the Air.

Am I too old? Are my reactions slowed down? Do my faculties preclude me from having any skill? I have not the slightest idea. The fact is that the controls of an aeroplane appear to be out of tune with my "man in the street" temperament. The more I study it, the more I reason it out, the more the aeroplane frightens me.

CONFESSION

An aeroplane frightens me because I consider it unsuitable for the uses that I ask of it, because to my idea it is defective. The Taison d'etre of an aeroplane is undoubtedly speed. In our times of rush, justifiably or not, we must go quickly.. The road has reached its maximum capacity and it is no longer enough; the air route alone allies extreme speed with security.

But there are no halting places in the air. In the air, at the end of a journey, one has not yet arrived, . . . there remains the landing. This is usually the moment for mistakes and annoyances a wonderful opportunity for a crash.

Aeroplanes appear to be strong. Why then do they break?

Statically the aeroplane is "superabundantly indestructible," otherwise the technical authorities would refuse its permission to fly.

But the aeroplane is not called upon to fly in a laboratory tunnel with a steady flow of air. Its life is one long struggle with air turbulence, and the argument may end in blows and wounds.

AEROPLANES MUST NO LONGER CRASH!

On commercial airlines we can insist upon multiple engines: we shall no longer need to fear engine failure.

But the private aeroplane is in the hands of unprofessional unreliable people, whose imprudence may cause an accident. How shall we intervene? Shall we treat the symptoms of the disease? No! We must go back to the root of the malady. If you filter dirty water, you will never obtain clean water.

WHAT IS WRONG WITH AVIATION SEEN FROM BELOW?

Thinking people agree that progress has simply changed the cause of accidents. In days gone by, the aeroplane broke through weakness and through faulty proportioning of the controls. Today it is strong and perfected; but it still falls in a spin.

The stall, the origin of the spin, is like a sword of Damocles, suspended over the head of all aviators.

Safety slots have palliated the trouble, and one can amuse oneself by flying with one's tail dragging in a position which might become dangerous if the engine stopped near the ground, they are, moreover, a weight and a complication.

Aerodynamic cleanness, so desirable for speed, produces aeroplanes which require long runs for landing or take off: such aeroplanes require experienced pilots.

Flaps may be used as air brakes to reduce the cleanness, but the aeroplane can still stall. We can use the low wing type, and thus create a cushion of air below the wing when near the ground to help us to land and take off at slow speed. But we lose lift from the middle of the wing, and so we increase the span and get a trailer machine! Is this a good solution?

And if we cannot see the ground so well because of the low wing, we argue that the bonnet of the car hides the road---or that the wing is a good shock absorber in a crash! We gain on the swings what we lose on the roundabouts! I do not like these arguments.

Speed! always speed! do we million ordinary men really want to go great distances in the twinkling of an eye? Will our materials always stand up to such folly?

The beautiful private aeroplane hides secret vices. It remains what it has always been and always will be in its present form,

A WAR MACHINE.

Here, for instance, is a beautiful low wing type, of remarkable performance . . . it doesn't sell. Its maker has thought of everything except what the public needs.

In the sacred cause of aerodynamic cleanness he has placed his seats in tandem! Is it a sign of the times that we can go honey mooning with the bride behind murmuring words of love to a rubber tube...?

Seats side by side, a folding wing placed high, giving a complete view of the countryside these are the sine qua non of air touring and of air safety. The man who does not agree with this statement is lacking in all critical sense. One must distinguish between the war arm and the civil machine. A car has wheels a cannon also. Otherwise there is no resemblance. The client "WAR" has money the individual, if he has any, does not spend it without thinking twice. The business man can risk large sums, on the condition that it is worth while.

The aeroplane is a merchandise which does not pay. It is too expensive for what it is. Designers have adopted bad habits from association with the client "WAR." Since they have turned their attention to the private buyer, they have not changed their ideas. Sales remain limited. The makers have not understood the problem.

THE TROUBLE WITH AVIATION SEEN FROM ABOVE

Take the young men, all interested in sport, full of life and strength. Assume that they have never seen an aeroplane. Pick out one of them haphazard, it doesn't matter which, and put him in an aeroplane. Say to him, "'Pedals are for steering; by moving the control column this way you re-establish your lateral balance; this way, you rise or you descend. With the throttle you regulate the power of the engine." Start the propeller and leave him to his own devices. He will not have flown 100 yards before he is in a spin. What is more, the other nine young men will also spin.

THE TRUTH

Dear reader, I shall not go further in this book, into which I have put all my heart, without unburdening myself to my friends who read me, my friends, who have taken me for a knowledgeable

pilot! Today I can face up to things. I need no longer hide anything. There is no need to lie. Nothing to be ashamed of in admitting it:

I am not a Pilot.

Does this mean that I must keep quiet as if dead? That is another story, and I refuse to be inactive.

I had the luck, as I was making trials with the Flying Flea No. 1, to have a good pilot as my neighbor, an old War instructor, who possessed an aeroplane and did not hesitate to make use of it. Although he did not believe in it, my formula interested him: my machine had a propeller which made a draught: my wings cast a shadow on the ground: my wheels traced a rut on the wet ground. . . . I was there for the pilot of an aeroplane . . . thus an aviator . . . and thus a friend.

He offered me the hospitality of his hangar and that early Flying Flea, like a chick under the wing of the mother hen, found shelter under the half wing of the Potez 36 of that date.

It is thus that in the machine of this good friend, of this old adviser, who did not query expense when it was a question of flying or of making people fly, I acquired during the Summer of 1932, thirty hours of flight.

These flights were not only passenger flights, like, a bulky parcel, but navigation between intervals of dual control, repeated lessons in takeoffs and landings, of flights among the clouds by instruments, of observing and maneuvering, etc.

With him I made numbers of journeys in all directions over the North of France and Belgium, not by following natural landmarks, but by holding the nose of the plane on the straight line traced in advance on the map, that is to say under the most, difficult conditions.

He did not allow me breathing space. He did not tolerate one minute's idleness. I flew... but I worked hard. I understood then that aviation seen from the ground did not in the least resemble that lived up a loft. My thirty hours' flight were thirty hours well spent.

Did I progress,? Read on and find out

FIRST FLIGHT: "LET'S GO"

I take the joystick and place my feet on the pedals. My left knee trembles a little. I cannot stop it. Does

My friend see it?

My lessons were a constant terror. "Hold it with your foot and feel it!" Feel the machine? I don't feel anything! The joystick is there: it is a tube with a wooden handle, just like all wooden handles.

...Speed? The engine? The altitude? Are we going up? Are we going down? I haven't the faintest idea. I do not "feel" anything. There is no sensitiveness, no smoothness in this massive machine which hurls itself through the atmosphere in all the fury of its 100 h.p.

A machine quite beyond me. The joystick pushed at my hand, terribly. The machine was remonstrative and objected to obeying

me. It was heavy and all my maneuvers were delayed. I tried to turn, my eyes fixed on the speedometer. A little more pressure with my foot, a little more on the joystick. - - . I banked. Too much! I pushed the joystick in the opposite direction to get right again . . . my friend grasped the controls; I was in a spin. Since then, each time that I try to turn other wise than flat and very gradually, my instinct makes me cross the controls.

Luck has so arranged oh, my guardian angel that I should pilot the Flying Flea before taking in hand seriously the control of an aeroplane. My reactions were formed by sane instinct. All the stuff learned in ten consecutive hours of flying an aeroplane vanished in 100 meters of a flight on the Flea. My natural instinct is stronger than my will. I have had too much training in manipulating logically a pencil, a file or a blowpipe, to make a movement which is opposed to sound reason. My being refuses to register a reaction opposed to the instinct of self preservation. In a plane, if I lose my head, I am done! It is quite clear: I am no good at it. I am incapable of piloting an aeroplane.

"NO'S" AND "NOTS"

What is it in fact, this learning to fly? To be precise it is "to learn not to fly wrong." The aeroplane is the only machine upon which it is necessary to learn how not to put oneself in danger. In an aeroplane the danger is permanent. It forms part of the business. To learn to become a pilot is to learn: Not to let oneself fly too slowly. Not to let oneself turn without accelerating. Not to cross the controls. Not to do this, and not to do that. To pilot is a negation... And when your teacher reminds you of this with great shouts that does not help to reassure you!

Let us take the control column and reason out the movements.

1. The Vertical Plane: if you push the stick forward, the plane descends and gathers speed. If you pull back, it rises and slows down. The control is very sensitive, or rather, your body is very sensitive to accelerations in the vertical plane. If one exaggerates the movement a little, the passenger soon begins to feel sea sick. To the beginner, this control is most pleasing. It is a pleasure to lower or to raise the nose on the horizon. One feels that one is "getting results."

Joy changes to dismay in rough weather. The beginner does not manage well in rough weather, because to foresee the gusts of wind is an art which one only acquires after some time.

Why foresee? because the control stick is passive. It indicates nothing. It is not alive. In an aeroplane, the beginner realizes that he is out of position only after it has happened. A gust comes. The aeroplane leaps upward. The human reactions only intervene afterwards. The control of an aeroplane in the Vertical Plane is

A DELAYED ACTION

In full flight, high up in the sky, this delay is of no consequence: it is quite otherwise when near the ground. This type of delayed control has caused numbers of aeroplanes to stall to fail, and to crash. This is an inherent vice.

2. In the Horizontal Plane: if you carry the control column to the right, the plane banks to the right, and vice versa. But at the same time as it banks to the right, it tries to turn to the left. The rudder must be moved to correct the movement.

It is necessary, in all horizontal movements of balance, to bring into use an extra control the rudder which has no connection with the primary reaction.

When you allow the aeroplane to slow down by raising its nose, the rudder loses much of its corrective action and the movement of the aileron which, according to your reactions, should have made you lean over to the right, starts your machine rotating energetically towards the left, although remaining level: you are in a spin.

3. To Turn: the rudder is not only a corrector, as we have just seen. It is used also for turning.

In a car, on a bicycle, to turn you move the handle. bar or the steering wheel in the direction in which you wish to turn. The most imbecile learner driving a car, even a delicate woman, turns the steering wheel in the right direction at once. It is inborn. It is the natural reaction.

For the aeroplane, somebody decided otherwise. And since to have made it a hand control would have complicated the control stick, the work has been confided to the feet.

There are intelligent feet; there are stupid feet... The feet are bucolic things from which one must not demand any skillful or accurate movement. Only dancers have skillful feet, because they have learned to walk a second time. Thus, to steer an aeroplane with the feet necessitates training. The same training given to the bands, would lead (don't you agree?) to much greater skill . . . To turn slowly, the rudder is all that is necessary. You turn. From below, your pals are making fun of you because you, a young pilot, are making a flat turn by skidding.

To turn respectably, without going to the lengths of a vertical turn, you must bank, that is to say bring into action yet another control the ailerons which have nothing whatever to do with the initial intention of turning.

Thus, lateral control and the turn call for two combined maneuvers in one direction or another according to the circumstances, which are very different. One can turn or correct oneself with the ailerons or with the rudder, sometimes with the controls working together, sometimes with the controls in opposition, sometimes banked over, sometimes flat. . . .

All this is naturally not very clear and continues to cost human lives even those of very good pilots. The rudder and the ailerons have a double use, can counteract each other, and are not used in accordance with our natural reactions.

To be an aviator, under these conditions, is to carry out something extraordinary, is to become superhuman, almost somebody abnormal, I nearly said unbalanced!

The ordinary average man in the street, such as I am, cannot compete with such demands. Annoyed with myself, I watched my friend fly; he crossed the controls just as much as I, but his "air sense" as an old pilot controlled his speed and his evolutions.

How, many pilots turn correctly?

It goes without saying, that the amateur's aeroplane is made of wood, because wood as a famous French designer has said is the "metal" about which we know most. Metal machines may suffer from resonances of the kind which break a bridge if troops do not

"break step." As yet official tests of structures at rest do not reproduce the conditions of safe use of private aeroplanes, and as a consequence the aeroplane, in its present form, is defective. It leaves in the hands of the pilot possibilities of a catastrophe.

It is therefore not surprising that to have the right to travel in the air in a vehicle which is so imperfect, the aviator must show exceptional physical qualities, pass very severe examinations of professional aptitude, submit periodically to a compulsory medical examination, and be of perfect physiological balance.

The organization of aviation, powerless in face of technical imperfection, can only act administratively.

It does what it can. Its activities end there. If there is a crisis.. the engineer alone is responsible.

The aeroplane is calculated to too narrow margins. It lacks the necessary strong points. It cannot be easily inspected

It is difficult to dismantle.

It is weak and difficult to repair. It is too long in the leg.

It is deformable under stresses. It is too slow in the air.

It is too fast on the ground.

It lacks visibility, to see where one is going. Its controls are irrational. . . .

The trouble is at the root; a wrong conception.

A successful neck, breaker!

There are not enough engineers who fly.

There are not enough pilots who study engineering. That is why, for the public, and for myself The Aeroplane is Frightening.

Aeroplanes fly! They even fly very well. In...spite of its inefficiency, the present aeroplane is a marvelous instrument.

Man's faculty for overcoming the defects of tools Which he uses is admirable. Our senses adjust themselves to the defects of our creations. Nature is always Strongest. Imagine, therefore, what might be our skill, if the instrument did not make matters so difficult or the user!

PROBLEM

Having located the trouble, let us analyze it. Many inventors search for new arrangements. The helicopter as its followers the autogiro is almost perfected. Perhaps one or the other but has the formula

the normal "aeroplane" said its last word? Has it reached the end of its feather? Can it not be modified? list it be rejected entirely? .

I think that plenty of wings will continue to glide along the aerial route.

We amateurs who wish to fly will look for the solution in the formula which are already known and which have been consecrated by use.

We want to work things out, to perfect them. We will invent, yes, but with extreme prudence.

Amateur flying is a problem:

OF SECURITY!

1. Security of construction;
2. Security, by means of a margin of speed
3. Security by stability of shape;
4. Security by rational controls for flight.

There is also at the same time a problem

OF ECONOMY!

1. Economy of materials;
2. Economy of dimensions;
3. Economy of mechanism;
4. Economy of upkeep.

A primary truth is that everything which flies, must on principle

BE LIGHT

Lightness means smallness.

Smallness allows of small power. Small power means cheapness.

IS NOT THIS LOGICAL?

This golden ladder, did I not descend it? Let us

form a hypothesis. Let us say:

Weight of the engine equals weight of the airframe.

Engine plus airframe equals load. This is the formula which I wrote in "Les Ailes" of the 28th January, 1932, regarding the aeroplane of less than 100 kilos empty weight.

It is even, I obstinately believe, possible to make a machine of the same weight as its pilot, i.e.

The Aeroplane of eighty kilos.

To fly very cheaply one must make something very small.

CHAPTER IV

AERO-TECHNIQUE

THE BIRDS

The flight of birds was the object of my first studies. Before seeing an aeroplane fly, even before the existence of aeroplanes about 1903, I had a fairly clear idea of the various kinds of natural flight. I looked at the vultures. I saw them gliding, extending their wings to maximum, spreading their tails, carrying their wings well forward which gave them that slow flight which was necessary for watching the ground. Sometimes, when they went a little too slow, they carried their wing tips rearwards, or gave a little flap, in order to regain the balance which had suddenly become unstable.

A PARADOX

All sorts of birds, vultures, larks, crows and sparrows, under all kinds of atmospheric conditions, appeared almost perfectly stable. In all my life I have never seen a bird make a bad landing.

On the other hand, I saw them fly continually at that very slow speed which in aero-technique we call the second regime of flight (flight beyond the stall) risking loss of speed. They fly all the time like that. For an aeroplane to fly like that is to risk imminent danger. What is safety for one, is danger, for the other. I felt compelled to seek an explanation of this paradox.

CONTRAST

Unlike the aeroplane, the bird is never suddenly lifted or dropped against its will. It is free in the air because it controls directly the amount of its lift. It is quite logical to add to one's lift when one is falling and to lessen one's lift when one is being forcibly taken up.

What the bird can do, the aeroplane cannot.

I see the explanation in the following fact that:

A bird's flight == direct and immediate control security.

An aeroplane's flight = delayed control = danger.

STABILITY

I made a test; on a bicycle I pulled behind me by a long string a scale model of an aeroplane which had flown very well with a screw and rubber motor, and then a model kite mounted on wheels and balanced so as to glide properly. The aeroplane always took the air with an up and down movement which increased; the kite took off and flew like an aeroplane steadily, and followed me correctly.

I repeated the test, but balancing both of them like the kite was balanced. The kite took off at once as usual and was stable; the aeroplane took off and immediately got into a spin turning round and round on the end of the thread. I formulated the following explanation:

The aeroplane has one single wing of great span, which gives it a very good efficiency and great controllability, but it wants a pilot. The kite, on the other hand, has multiple wings with very large tail surfaces. That is to say, its lift is divided, which gives it a stability of form and a straight line flight. It does not need a pilot.

BALANCE

We saw just now, when studying the lateral control of an aeroplane, that at times the use of the aileron has to be corrected with the aid of the rudder. You use the hand and the feet at the same

time, but they must be used in the correct manner, of the correct amount, and sometimes against one's ordinary natural reactions; the result is a combination which is not very sound and in certain cases causes accidents.

Road vehicles, ships, dirigible balloons things which go on the land, on the sea and in the air are all stable machines with a system of directional control which allows them to go the way they want to.

These stable vehicles do not possess any apparatus for lateral control. In the air, the parachute, the kite and the dirigible balloon are all naturally stable as a result of their shape. Alone among all transport machines the aeroplanes has to be supplied with lateral controls. It is the only one which is unstable and dangerous by reason of its design.

That strikes one as an aberration of a mad enthusiast. Since the spin, resulting from crossing the controls, is a natural burden on the aeroplane, if we do away with one control we cannot cross them any more. That is logical isn't it? Let us make a choice which of them we shall suppress.

It seemed to me that it would be extremely pleasant to be able to do away with that kind of small fan which we call a rudder, and which when one is going slow, or has lost flying speed, beats the air in vain. The lift of an aeroplane is a tender plant which grows from speed: that is the defect, a well known defect, which the autogiro escapes. The action of the rudder is a function also of this speed. That, from the point of view of security, is also a bad vice.

But we cannot demolish everything at a single blow. On the whole, up to date, the rudder is the least defective of the aeroplane controls: we may as well keep it. Well, either the rudder or the ailerons must be done away with, and therefore if we keep the rudder it must be the ailerons which must be suppressed. The kite is perfectly stable and has not got any ailerons.

It is quite clear that if we do away with the ailerons certain results will follow, and that if we want to gain the qualities of the kite our machine must diverge from the formula on which aeroplanes are built and ally itself to the kite formula. Under these conditions the aeroplane becomes a kite with an engine, and need only be controlled in altitude and direction.

The maneuvers are easy, independent of one another, and always the same. To follow the ordinary sense of our human reflexes:

ONE: OUGHT TO BE ABLE TO FLY WITHOUT LEARNING.

ONE OUGHT TO HAVE ABSOLUTE SECURITY.

So now we are going to study. rather carefully in the following pages our programme of innovations. That is, we shall study:

- (a) the direct control of lift,
- (b) the division of lift between the two surfaces,
- (d) the whole control by the hand without using the feet.
- (e) the suppression of the ailerons, and

That is evidently quite a new formula.

AERODYNAMICS CENTER OF PRESSURE

The pressure of the wind on a wing may be imagined as concentrated on a line along the span of the wing at approximately $\frac{1}{3}$ of the chord behind the leading edge of the wing. As the incidence of the wing to the relative wind is changed this center of pressure is displaced. In the case of a flat plate, or a wing which has a straight center line, this displacement is in a stabilizing sense: as the pressure grows with the increasing angle, so the center of pressure moves backwards, which tends to reduce the angle.

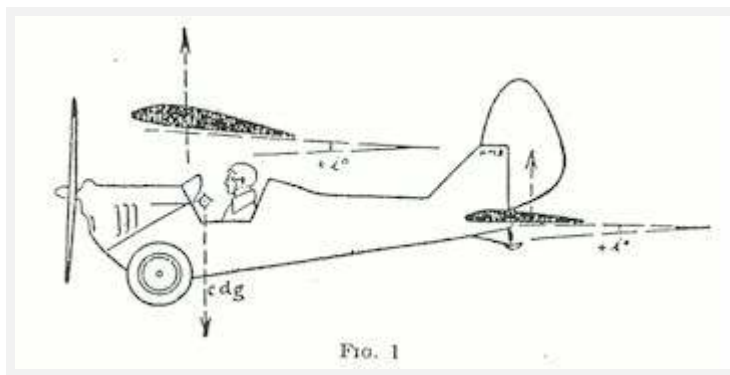
But with ordinary curved wings the center of pressure moves in the reverse direction, and is adverse to stability. If the aeroplane increases its incidence, the center of pressure moves forward and tends to still further increase the incidence and vice versa.

Since the curved wing has a good "lift" or carrying power, we use it and we correct the instability by adding a tail plane set at a lesser angle of incidence than the wing. The variation of the efforts of the wind on the two surfaces is unequal and we can arrive in this way at stability of form.

BALANCE

An aeroplane is well balanced and stable if the center of gravity is a little ahead of the center of pressure, but to achieve this we have to set the tail at a slightly negative angle of incidence. In this case the tail plane adds nothing to the total lift, and even detracts from it: it also acts as a brake or resistance.

We call this condition having the C.P. forward. We can, however, get a better all-round efficiency without losing too much stability if we have the C.P. a little back, that is to say with the center of gravity a little aft of the center of pressure by 5 or 6 cm. (Fig. 1).



We now get a little lift out of the tail plane, but always a little less (because of the lesser angle) per.. square foot of surface than we get on the main plane. But now we get a reaction on the control column, which under these conditions pushes against the hand instead of pulling on it, and this is against the natural instinct of the pilot.

If he shuts his eyes, after a bit his arm tires and his hand yields: the aeroplane starts to climb, slows, and stalls.

An aeroplane ought always, under all conditions, to pull on the hand to pull on the hand like a horse pulls on the bridle or the reins.

The more one pulls the slower one goes. The more one "gives rein" the more is the animal or the machine freed from the restraint of the rider.

One's hand ought not to force the thing, but to hold it back: your control is demonstrated in this way. There is no meaning in pushing.

Pushing with the hand is a sort of act of correction voluntary and tiring. Pulling is an act of association or cooperation, instinctive and easy.

The jockey pulls on the bit: the rower pulls his oar: the cyclist pulls the handle bar. Isn't it reasonable that to rise a pilot should pull on his control column?

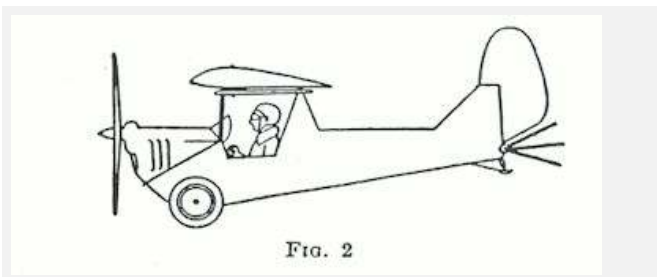
A control column which pushes against the hand is contrary to good sense, contrary to the instinct of self preservation. It is an anomaly.

I have not time here to denounce all the follies which have accumulated in the design of aeroplanes. After a year or two of experience the designer adds a spring to fight the stick which pushes against the hand: it is a shortsighted battle against the evil results and not against the origin of the evil. It shows a weak imagination. Well that's enough of these generalities. Let us leave aviation to the aviators let us go off on our own voyage of discovery with our guide.

To begin with I decide to control the lift directly. The Bird : The bird, which is extra ordinarily stable, controls its lift by opening or closing its wings. It works on the principle of variation of surface. It has joints, and staggered feathers which overlap one another, and muscles, and nerves a whole heap of living threads which play in the thickness of its wing.

Nature uses materials suitable for her purpose, pliable like India rubber, but less hard. Alan has at his disposal different materials, not necessarily worse, but he must use them judiciously.

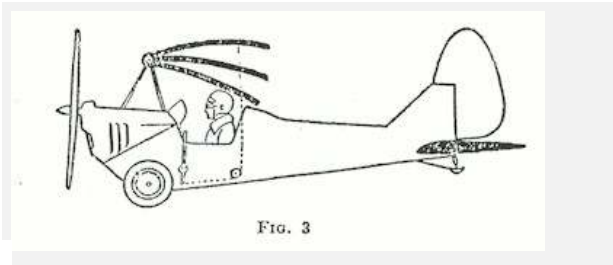
Man : Man can alter the lift of his wing by varying its incidence. That is a good way to do it, but the delay in the control is bad for as you see (Fig. 2):



1. The wing is solid with all the inertia of the mass of the machine.
2. The stabilizing tail is affected after the turbulence has struck the main wing.

There is delay in the pilot's control.

There is delay in the inertia of the mass of the aeroplane.



It is therefore perfectly logical (Fig. 3) to

1. Detach the wing from the mass of the body.
2. Join the wing directly to the control stick through a movable control.

The tail plane now can give lift and be fixed.

The wing is pivoted about an axis which is so placed that under all conditions the C.P. is behind the pivot point.

In this way the rear edge of the wing is always trying to lift, that is to say to pull on a cable which is joined to the control column.

The stick pulls on the hand like a horse's mouth pulls on the rein, establishing a feeling between the rider and himself.

The rider can feel his mount.

The pilot can feel his machine.

That, Is something which hasn't been done before.

All is in order. I start to take off. The machine gathers speed, lifts its tail and takes up its flying position.

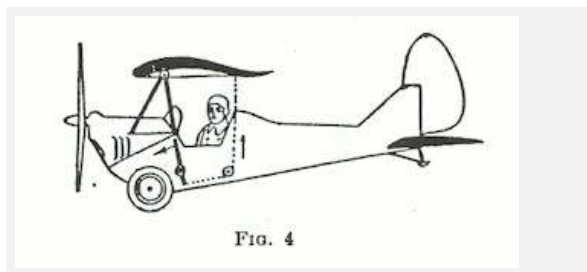
I pull the stick to me. The wing offers an angle to the wind and I take off.

I climb. To gain speed, I let my hand go forward. Hullo! something is not working properly! The control column pulls against me harder and harder and I have to hold on with both hands to keep the machine up: it is trying to dive to earth. If this goes on increasing, my controls will break and that will be the end. . . .

What is the matter? When I let my hand go forward the C.P. which was perhaps at 5 cm. in rear of the pivot point at first rushed back to perhaps 20 cm. when I diminished the incidence. Under these conditions my controls were carrying a great part of the lift, i.e. of the weight of the machine.

In an ordinary aeroplane the pilot doesn't know when the rear spar and rear bracing is carrying all the load. The time comes when the wings break. The pilot doesn't feel anything wrong. The Flying Flea warns him! It is of first importance to stabilize the movement of the C.P. We do this by turning up the trailing edge of the wing, which gives a sort of double curve to the center line of the profile (Fig. 4). It is rather as if one had stuck a small stabilizing (i.e. negative) tail behind the wing.

This new wing is stable of itself, like a flat plate, but it still gives a good amount of lift. We would like here to comment severely on those who have designed wings for aeroplanes or gliders of a very high curvature, and recommended them to amateurs as offering a quick get off. They have on their consciences any number of serious accidents.



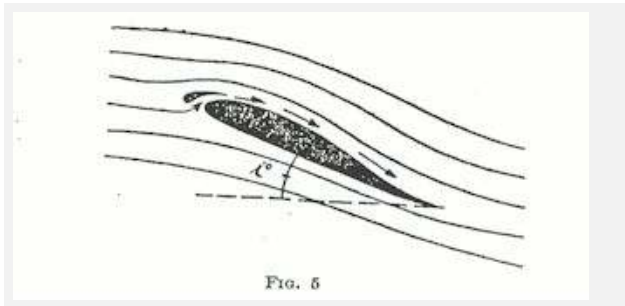
Why didn't they try out their first machine themselves? they would have learned in the best school.

The new arrangement is usable. The other was not. Now we find that each increase in incidence is indicated by an increase in pull on the hand of the pilot. The pilot is in full and correct touch with his wing. His control is as good as that of a bird: he has a living wing.

The incidence of the wing is free of the mass of the machine, but is in connection with the muscular system of the pilot who has an elastic and sensitive wing. Whether I fly level, climb, or come down I handle this gentle pull which, as it passes over the turbulent air, makes me feel that my machine is alive.

LANDING

The ground, two yards below my wheels, rushes past at sixty miles an hour. I stop the engine. The ground gets nearer. I am still going too fast to land. I pull on my hand; the wing comes to a greater incidence, lifts more and keeps me up, while decreasing the speed. I am now going thirty miles an hour. I pull more and more.



Suddenly the aeroplane drops and falls like a stone. If I had been a little higher I should have smashed it.

What happened was that as I increased the incidence of the wing I passed the point where its lift is greatest and suddenly the air which had been quite ready to glide smoothly over the upper

surface had torn itself away and merely left a zone of eddies which are of no use for lift.

If one could retard this "unsticking" of the air, one could land much slower.

One way of doing it is to alter the direction at which the air meets the main wing by the device of a little wing suitably disposed at its leading edge. This is the slotted wing or safety slot which we put on touring machines (Fig. 5).

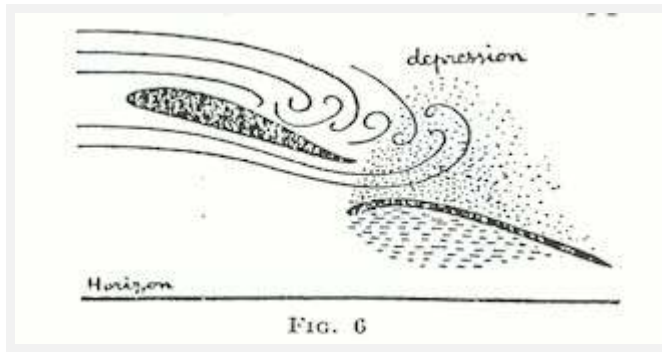
With this slot the stall is no longer dangerous, and if one puts the machine voluntarily into a spin one can easily get it out, provided that the engine does not cut out. If the engine cuts out in a stall, the tail plane loses its effect.

One real argument against wings with a fixed slot is that the little wing in front of the wing may take five miles an hour off the speed. That is a lot when it is so hard to get those last few miles! When does the slotted wing do useful work? At an exaggerated angle of incidence. That is not a very satisfactory attitude at ground level. Therefore, it is not of much use for landing or take off.

At a height it will help you to get out of a spin, but lots of aeroplanes can get out of spins which have no slots. Therefore the slot is employed only to a small extent. The slotted wing is not the great, beautiful or really elegant solution of the problem of safety. Really one ought to fit it to a pivoting wing. It would be more rational. In practice a lot of aeroplanes do not fly so badly without it.

WING WITH A SLOT

I thought along different lines. The air "unsticks" at the rear edge of the wing: the nose slot is in front of the wing. Here again we have an indirect action. What would happen if I took a wing from which the air was about to "unstick," and brought its rear edge close to another wing which was carrying normal lift (well away from the stalling point). (Fig. 6.) This other wing has on its forward upper surface



a very strong depression. This depression ought to draw towards it the air which is leaving the forward wing and bend it downward.

This bending downward of the air behind a wing ought to delay its breakaway from the upper surface. The leading edge slot works by pressure. My second wing works by suction. We know that in aerodynamics suction is much more powerful than pressures.

The leading edge slot is placed far away from the zone where the air breakaway tends to take place. My second wing operates quite close to that zone.

The fixed leading edge slot slows the aeroplane by five miles an hour. My second wing adds to the total lift: it is a genuine, wing and not a drag-creating accessory. The pressure on the underside of the front wing and the depression on the upper side of the rear wing create in the gap a violent rush of air which will in addition have a sort of venturi effect and will help still further to pull down the air leaving the front wing, and delay its breakaway.

To be exact, instead of placing a slot too far away at the front of a wing, I put it in the rear in a good position. We have now a biplane, with wings of extreme stagger, almost a tandem but not quite one nor the other

CONTROL OF FLIGHT-STABILITY OF FORM

The rear wing does not work in virgin air: this air has already worked on the front wing. It has been bent down and slowed.

The rear wing therefore lifts less than the front, but it will lift more as the front wing is taken further away, or if one wishes, higher.

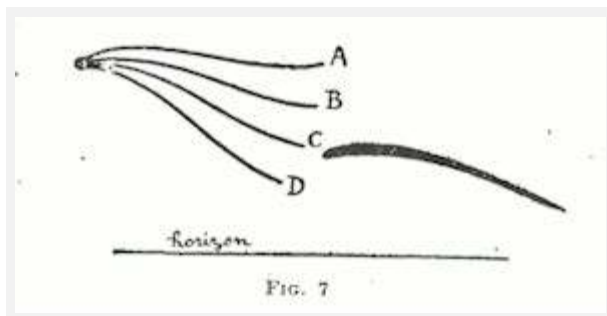
The gap in my wing with slot is variable in two ways, voluntarily and automatically.

First Case : It is variable by reason of the actual pivoting movements of the front wing. Let us look at Fig. 7 which shows four characteristic positions of the wing.

In A the front wing is out of action and carries no load. The rear wing works in virgin air and is working at maximum efficiency. The rear wing is lifting too much and the front wing not at all: the machine falls forward and dives.

Therefore a real stall is impossible. Under all conditions if the pilot lets his hand go forward the head of the machine falls.

In B the front wing is lifting. Its influence on the rear wing diminishes the lift of the latter. This is the normal position of flight at small angles of incidence.



In C the front wing is lifting a great deal and the rear wing very little. The slot effect is at its maximum. This is what the French call "the second regime of flight" very tail and nearly stalled (for landing). Between B and C are all the normal conditions of flight cruising, climb, correction of bumps, etc. In D the front wing completely masks the rear one. The air breaks away from the top of the wing, and there is turbulence under the wing.

This is flight at maximum drag

(a) for stopping the machine on the ground after landing.

(b) for slow approach when forced landing: descent is almost vertical like a parachute.

This last case is used for forced landing under difficult conditions in the country, and allows one to get into a small field without risk of over or under shooting.

When twenty yards above the ground one lets the hand go forward to pick up speed and land tangentially.

Second Case : If the front wing remains fixed the gap is still variable according to the relative position of the angle of incidence of the wings considered together. Everything else being unchanged (Fig. 8) at low angles of incidence the rear wing is working more in the air affected by the front wing, and its lift is less. The machine tends to drop its tail. At a greater angle, the rear wing is more freed from the influence of the front wing, and its lift increases. The machine tends to drop its nose. A position of equilibrium exists between the two positions. Stability of form thus does

not depend any longer on the incidences of each wing considered separately, but on the influence of each on the other, measured by the incidence of the whole machine.

The slot or gap effect gives the rear wing progressive independence of the front. A tail plane becomes superfluous (Fig. 9).

Our tandem biplane, which is neither thing in fact, becomes a single wing with a gap, and in accordance with the most advanced practice becomes a tailless plane.

To sum up we have:

1. Lift directly controlled the "living" wing.
2. A logical form of slot a "gap."
3. Lift divided between the surfaces.
4. A "tail" of great power.

Isn't that a good achievement for our flying kite?

AERO KINETICS (Kinetics are "the science of movement".)

FORE AND AFT BALANCE

When an aeroplane meets an up gust the following events occur in order:

- (1) It is lifted before the pilot thinks of reacting (physiological inertia).
- (2) The pilot pushes on the stick, to lift the tail.
- (3) The whole mass of the machine under the influence of the elevator changes its attitude to diminish the incidence of the wing (mechanical inertia).

At the moment when the machine has too much lift, the tail plane comes in to add more lift; at the same time it adds to the drag, and inclines the machine to lose speed under conditions where it is already heading that way.

The pilot's perception of what is happening, the command of his tail plane, and the movement of the mass of the machine are all delayed: the aeroplane leaps like a sheep (Fig. 10).

The wing of the Flying Flea pulls on the control stick. The pilot gives to the pull by letting his hand move. The gust passes. The Flea has kept on its straight trajectory. Control has been effected without delay.

When a descending wind tries to drop an aeroplane at the very moment when the machine lacks lift the tail has to come into action to still further lessen it. There are the same delays in the action as before, but reversed.

In the case of the Flying Flea, the wing pulls less on the hand. The pilot's hand recognizes this, and

automatically gives more incidence without any delay.

The Flea cannot be bumped down onto the ground by a gust.

The machine takes no heed of short disturbances. When the trouble is prolonged, it naturally takes up an attitude to meet it.

Any flying machine wastes less of its power and time the smoother its trajectory, and the less the passengers are knocked about the better for their comfort. In this case we must give full marks to the Flying Flea.

On landing, a hump on the ground throws a flying machine into the air. The sudden alteration of angle of the ordinary aeroplane pushes it up into a zoom and you need some skill to get it back to ground smoothly.

The Flea lets its wing go loose immediately. It loses all its lift and its weight presses it to the ground.. It is as if it had no wings, while its large tail keeps its attitude correct in flying position.

The Flying Flea lands without "proposing"! That's one more good mark for it.

When taking off, there appears an obstruction after fifty yards run. The pilot of the Flea gives a momentary pull to its wing to leap the obstacle, and then carries on to gain flying speed. The long fuselage and the inertia of the mass of the ordinary aeroplane rule out this maneuver.

The pilotage of an ordinary aeroplane is as much delayed control as would be the case of a motor car steered-by the rear wheels. The general trend of the motor car is to carry its mechanism, both power plant and brakes, in front. Aviation ought to obey this law, which its speed enforces on it everything which has to act in front: everything which is carried passively behind. The Flying Flea is a step forward in this direction.

SUDDEN LOADS

When an aeroplane is pulled out of a steep dive a prudent pilot will straighten it out gently. His own weight pressing him onto the seat gives him an idea of the extra load on his wings due to the sudden deceleration. This feeling is rather vague in the case of the ordinary pilot. A ham-fisted one by pulling out too quickly might leave his wings behind him. It is in recognition of such unavoidable errors that the factor of safety imposed by air officials is seven for ordinary touring machines, and ten or more for fighting planes, that is to say, the wings can carry up to ten times the normal load before breaking. A man would die under an acceleration of 10 g., when he would weigh 700 to 800 kilos under the effect of a sudden deceleration.

The lift of the wings of the Flying Flea is directly controlled by the pilots hand. The center of pressure of the wing is aft of its pivot line. Under these circumstances, as I have said, the pilot always feels a pull. Since the wing is of stable form the pull is uniform, when in stable flight. You can fit if you like a balancing spring to relieve the pilot of this constant pull and allow him to let go the control. Such a spring works in the right direction for stability.

A gust, or a pull out, or a tight turn which loads the wing more than normal is at once recognized by the hand of the pilot, just as he would know if someone doubled the weight he was holding.

If the aeroplane wings are holding a doubled load, the pull on the hand is doubled.

If you ease the hand the load is reduced; if you pull it is increased. The pilot of a machine, with the "living" wing is not such a fool as to pull like grim death on his control column when that tells him that the load is excessive.

Even the most inexperienced, thanks to this living wing principle, knows at all times the state of his security. Ah! if only the bracing wires and rear spars of an ordinary aeroplane could cry out!

Because of this living wing the factor of safety of the Flying Flea could well be greatly below the figure necessary for ordinary aeroplanes for the same security.

In really bad weather I control on my accelerometer so that my surcharge in the most violent bumps does not exceed 1.5.

A factor of four would give absolute safety. I have calculated the Flea to have a factor of ten. But I may have, no doubt, made a few mistakes and my amateur materials are not too good . . . but all the same my confidence is quite unshaken. Where the real aviator could break up his machine I shall never break it.

DIRECT CONTROL

The lift controlled directly by the hand gives The large rear wing, lifting and firmly secured at a fixed angle, makes a solid tail support in the air. Under all conditions even in the stall, and when coming down like a parachute, the machine lifts solidly, from the rear, on this constant foundation. This tail solidity gives.

SECURITY OF MANEUVER.

LATERAL BALANCE

In order to avoid "crossing the controls" we must do away with one of them.

The ailerons complicate the beautifully simple wing structure! When one has made a wing in a week, it is a pity to need another week for the construction and installation of ailerons!

Ailerons may vibrate or their controls jam: they are the main cause of spins. What a sad invention

These ailerons annoy us! Let us get rid of them. How then shall we ensure lateral stability? How shall we make correct turns?

Bank and turn are two evolutions which are closely related. One completed the other and their reactions are reciprocal. We will adopt the attitude in principle that, for a correct maneuver and a stable machine,

To bank is to turn. Turning involves banking.

To bank without turning, to turn without banking these are anomalies. The separation of these two maneuvers and the delay in control are the two great crimes of the aeroplane.

Kites, parachutes, dirigibles, and the Flying Flea are all stable in form in every direction by reason of the, lowering of the center of gravity under a spread of surface of small span arranged in a dihedral angle.

These assure that the reaction between lateral balance and turn are absolutely correct.

The kite with an engine needs only to be controlled in altitude and direction.

These two maneuvers, i.e. the pivoting wing and the rudder are controlled by the same column. Moved fore and aft the stick releases or pulls on the wing, and that makes the aeroplane descend or climb. Moved right or left the rudder is moved so that a turn starts to right or left. All this is done by the hand, and you can stamp your feet to keep them warm you don't need them for flying.

LATERAL CONTROL

Imagine that the machine is tipped over suddenly to the left. Instinct makes us carry our hand holding the control over to the right. Under the action of the rudder the tail swings out to the left and a turn starts to the right.

By reason of its momentum the machine tends to carry on in its original line, but the lower wing meets the wind first, while the wing which is too high drags in the wind. The "dihedral" effect causes the lower wing to rise at once in a manner which is astonishingly powerful.

Lateral control is therefore caused by swigs of the tail of which the effect is to bring the machine back onto its correct course. In short, the first bump which dropped the left wing started a turn to the left. When you correct the lateral turn and bring the machine back onto a level keel, you at the same time regain the lost direction.

DEFECTS

There is a slight delay in the response of the machine which is rather alien to the delay in the fore and aft control of an aeroplane. Here we get this delay in the form of a rolling movement: it is much less disagreeable than the jerky spasms of an aeroplane, and it is quite without bad consequences.

It is nevertheless true that an aeroplane pilot flying the Flying Flea will be rather disturbed for the first minute after that he won't give it another thought. The Flea rolls easily on the waves of the air like all boats rolling the sea waves but unlike them without pitching or shuddering. Another fault. It is clear that only on a short span can you replace the ailerons by a dihedral. The long spars and good aspect ratios which are so good for aerodynamic efficiency seem, at first sight, to be forbidden to us.

Without so intending I confess, we have followed the now tendency, which seems to be leading our aviation technique towards small aspect ratios. Do we not see in America and France two machines very much like one another one very probably copied from the other irreverently called coal scuttles which have their surface in the form of a semicircle where the span and length are equal?

TURNING

In order to make the Flying Flea turn, it is enough to carry the control column gently to one side. It takes up its own bank proportional to the amount of rudder. Then the ground begins to move sideways and it turns.

To turn sharply, a movement of the rudder of a greater nature makes the machine bank to 40, 50 or 60 degrees, as one likes. One then tightens the turn by pulling on the wing: it is the same as the tight turn on ordinary aeroplanes.

Whether one turns wide or short, whether one is a new or experienced pilot, one turns correctly because one cannot turn otherwise!

There is no question of crossing the controls, no danger of the stall, no side slip outwards or inwards, no question of over or under banking. As in a motor car, or bicycle or boat one just turns!

If learning to pilot is a matter of learning to turn, then in the case of the Flying Flea one turns without "learning," without being a pilot!

Take ten young people, sporting by nature, strong and fit. They have never by assumption seen an aeroplane. Choose one of them, it doesn't matter which one, and put him in the Flea. Tell him "The joystick takes you where you wish to go. Off you go!" They will all fly. Not one will break the bus!

My fourth innovation will thus be realized all the work of pilotage is entrusted to the hand. I leave to experience the task of confirming the ease of use of a machine which doesn't muddle its pilot but obeys his natural reflexes without any possibility of reversal of control.

Its obedience to his wishes is direct and quick. Each feels the influence of the other. The pilot lives with his machine. Freed from all fear and constraints to what skill he can not attain. The technique of flight control is that of the bird. The technique of balance that of kites with divided lift.

On what more solid foundations, with thousands of years of evolution behind them, could we base our conception?

The Flying Flea is a kite with an auxiliary engine. Isn't that another kind of flying?

In its realization it is a novelty, of which we will now examine the general arrangement and the details.

How did I design the Flying Flea?..

CHAPTER V

HOW I DESIGNED THE FLYING FLEA

ALTHOUGH the Flying Flea is a novelty it is nevertheless made for amateurs. Because it is destined for amateurs, and is I think (not to look too far ahead) above all a machine for getting a start in Air matters, I have paid more attention to the practical possibilities of its construction than to its technical efficiency.

The programme is to build and then to fly as quickly as possible.

The amateur is patient and skillful, but he is not a professional. Give him a machine which is unrefined, solid, simple, easy to make without excessive skill or special tools. Let us save him the task of calculating, of seedling solutions, even of choice. Later on he can use his initiative but this is not the time.

First comes flying: invention can follow. The amateur has only a moderate toolkit and not much room to work. He lives far from a flying ground. He must make everything with the means at his disposal.

The ideal programme is clear: to be able to construct his machine in a room of a length of 13 feet.

To fly! Yes, but first one must get acquainted with the machine and its surroundings. One must roll, do lots of rolling, often on rough ground. One ought to be able to go home at night happy, without having broken anything, without being discouraged by the prospects of the delay of a month to make repairs of doubtful soundness.

After having built one's Flea, one ought to be able to stow away the larger tools in their chest in the firm hope that it will be a long time before one has to touch them. Nails and glue: they are not so bad for a time! But you don't want to have to use them all over again after each time that you go out.

A very solid construction with a few strong points is necessary not only for the purposes of flight but with the machine is running along the ground. The previous chapter has been mainly concerned with the practice of flight: the Flying Flea has been designed with the double object of safety and ease of pilotage.

The requirements on the ground are that it should be small, simple, solid and practical.

These are the essential aims which have been kept in view during the working out of the Flying Flea, essentials which are the result of long experience where for each incident a remedy had to be found, now on the grass of the fields, now under the clouds at some 2,000 feet of heights and at risks not suitable for a father of a family.

The Flea is clearly the grown up brother of my earlier machines such as the HM8. The technique of construction for the wings and fuselage is the same. Only the disposition of the parts and their size is changed, and the air frames differ in that the time for building has been halved and the new machine is half as light as the older one.

Both of them have gained from thought, and from the suggestions and wishes expressed in correspondence received from amateurs. The Flea is a regular parasite and has ancestors on its escutcheon: it stays in the family.

THE FLYING FLEA

The flying kite dirigible parachute with auxiliary engine (call it what you will) is shown as a machine of a concentrated, massive nature glued to the earth. In the Workshop it seems very small, outside in the open it is minute.

"Surely that cannot fly?" ironically enquire the lookers on. When it is 2,000 feet up you would think it was at 5,000! When it has landed you cannot see it half a mile away! It disappears in the sky long before you lose the saw note of its roaring engine.

Its span (see Fig. 9) is 5 meters and its length 3 meters 50. It has so little spread that its two wings can be turned lengthwise and carried between the air screw and the rudder. In flight coming towards you it is like a big butterfly. When it is going away it is a tiny gnat. In an aeroplane the pilot should be sunk into his cockpit up to his ears the professors of aerodynamics insist on this but how awkward it is.

In the Flying Flea the pilot sits under the front wing nicely supported in the fuselage. His arms can rest on the cut away sides. By leaning over a very little way he can see vertically down. Without leaning at all he can see in front, to the sides, below and behind. When taking off and landing he can see the grass crushed by his wheels as they pass over it.

One ought to sacrifice a lot to the quality of visibility even technique and calculations. The Flea is a flying armchair.

SIMPLICITY

The surface plan of an ordinary monoplane consists of 2 wings, a center section, 2 ailerons, 2 fixed auxiliary surfaces, 2 slots, 1 elevator and 1 rudder that is 11 pieces in all. The surfaces of the Flea are composed of 1 rudder and 2 wings, i.e. 3 pieces in all. This layout offers solidity by its simplicity and efficiency. All three elements are active; there are no neutral surfaces, no negative (drag creating) pieces, no parts working at reduced efficiency or detracting from the lift.

The rudder directs the machine and takes care of lateral control. Both wings take their full share of the work.

The detail follows a plan of elementary technique

THE SINGLE SPAR WING.

No slots, no ailerons, no elevators, no complicated movements, no hidden cables, or levers, or mechanisms, metal work, etc. No gaps between moving parts: the Flea is not a corridor for air currents. The single spar wing is of a single piece. It is made of wood and covered with varnished fabric.

If you open up the wing you will see one box spar, some ribs (nearly all alike), a leading and a trailing edge, and a reinforcing lath and that is all.

Not a screw, or a bolt, or a steel wire.

Thanks to the single spar wing one can make the two wings and the rudder in eight days. Having no ailerons the wing will not flutter in the air. The two wings are alike except for a slight difference in span. The same spars, same details, and same fastening points.

Of a span convenient to an amateur they can be built and the whole Flea can be built in the room of an ordinary flat 3 meters x 4 meters (the minimum possible for a span of 4 meters). Put your work bench on rubber blocks so that your neighbor do not complain of constant tapping. With a normal spread of 5 meters a depth of 1m. 40 and pointed tips the surface of the Flea is 11 sq. meters. The double curvature of the front wing, and the work of the back wing in air affected by the front, these reduce the effective surface to about 9 sq. meters, which will serve for performance calculations. The aspect ratio (span divided by chord) is less than three. That of high efficiency gliders is twenty! And then what! Do they fly so well or not? I am bored with aspect ratio! Our little bus is handsome in its ugliness. Its appearance is striking it is indeed a Flying Flea.

LIGHTNESS

The simplicity of conception of its wings extends also to the fuselage. This leaving out the control column and the axle of the wheels is an empty box. The three flight surfaces, the empty box, five mechanical bits, an engine, two wheels and some cables we have here a total of 100 kilos not more. The five mechanical bits are the axle, the rudder axis, the control column, the wing and the engine supports.

A hand grip at the end of the fuselage enables one to maneuver this novel little bus on the ground.

A draw bar can be fastened under the fuselage so that the machine can be towed along the road behind any sort of vehicle. The tool chest and camp kit are quite useful to add weight to it and make it hold the road.

ACCESSIBILITY

Except for the lower portion of the control stick all the mechanism is exterior: the cables regulating the incidence of the wing, the rudder cables, the pivot and bracing of the wings: the engine also is installed in the open.

There are two poisonous things in an ordinary machine, the ailerons and the cowling of the engine: I have cut them both out. No more sheet metal which flies off or rattles. No more cowling. No more of the sight of an over heated engine!

And what heavy work, it is this of hammering and fitting! That's the way to save time! Ailerons and engine cowls represent weeks of labor and are never very successful. When the engine is open to the air it cools quite well and your spanner can test every nut in a good light. The up keep and inspection of a machine like this are therefore very easy. If we only put on transparent covering for the wings, we should surely get full marks from the Air worthiness Department.

SECURITY OF CONSTRUCTION

Because it is simple, and formed of a very few pieces it has been possible to make the Flea so strong that only a real crash could smash it to pieces. The story of my trials shows that it cannot be destroyed. I defy any ordinary aeroplane to undergo, without breaking into little bits, the astounding trials unexpected trials which I have put mine to. At the side of the table where I write this rests my Flea a bit battered by three months of winter storms in the open but sound and ready to fly again. And that will be soon!

Is the fuselage too solid? Yes, but it has not a swelling anywhere. Its sides look as if they were fastened on yesterday. The wing has kept its shape: the fabric has hardly slackened.

The Flea is a sturdy insect, a young rascal of the streets with a gay eye and dirty hands, ready to meet with a jest the happenings of the day. Perhaps its paint work is a little knocked about! What does it matter: it has done its job! This is not a show piece and then my brush is not tired and Ripolin still has colors in stock.

The Flying Flea does not age!

MATERIALS

Amateurs who know something about old furniture do not like white wood. Spruce is a white wood. It is an amateur's wood: with wood you are always certain. In order to simplify your passing the order on to your supplier, I have adopted only three sections of material, the small strips, the main lathe and planks.

There are just a few little blocks and spare pieces which you can get from some neighboring shop as you need them. The large surfaces are in plywood, which is very easy to find in two thicknesses. Our metal is just the ordinary mild steel of the ironmonger in sheet, in screwed rod, in drawn rod, in bicycle tubing, bolts, etc.

These are all materials which can be bent, or drilled, or filed without special treatment which is difficult for the amateur.

without arguing the point, I refuse to use the ordinary aviation metals such as alloy of aluminum and magnesium. In my opinion these are treacherous metals. Metal aeroplanes from the best suppliers sometimes break in the air. Constructions which have been closely worked out come to pieces. I have even had breakages in metal fittings of a simple nature and over size. Machines which go about on the surface of the ground can break, often without serious consequences, but an aeroplane must not break in the air, because the material consequences are too serious. In the case of the Flying Flea these are still more serious, because there would be bad moral consequences in addition.

For the same reason its designer has refused to use wings of a cantilever pattern, although they are so attractive. He has braced his wings with enormous cables with bolts "as large as that." Doubting perhaps still his professional experience, because quite a small article under the wheels will smash to smithereens all precise professional calculations, he stretched out his arm in full flight to test the main bracing wires. He found them scarcely taut!!! His mind was at rest.

SECURITY OF BALANCE

From my experience of amateurs who built HM-8's it is quite clear to me that the good balance of their machine is the thing to which they pay the least attention. It ought to be their particular care. In spite of the fact that I laid stress upon this, and gave very simple rules to them to work out the balance, very few took the trouble to follow them. So long as the aeroplane looked pretty in a photograph, they were quite happy. That was quite enough for them.

The varnish shines brightly, the motor is turning over, and airscrew is blowing. Hurrah! long live aviation. Off they go, and they make some sort of flight by pushing their hand hard forward in order to avoid the stall.

Correct balance, that is nothing which we can see, but it exists all the same. In an aeroplane balance too far back is a crime. The Flea does not need exact balance. It is so heavily loaded at the rear that it is not necessary, as on ordinary aeroplanes, to determine its center of gravity more or less to a cm. A rather heavier airscrew, a tank out of balance, a thin pilot or a fat fellow, none of these change its balance to any great extent. The waist measurement of the pilot only affects to some degree the height to which he can go, which is so much the worse for the stout one!!!

THE AIRSCREW REACTION

As the airscrew turns very close to the wing, and sends on to it an oblique current of air, it makes the side which originally inclines to lower itself lift more. The torque reaction is therefore (this is still my luck) exactly compensated, which enables us to have a pair of wings precisely symmetrical. We fly equally well with or without the engine. The landing gear is, proportionately to the rest of the machine, the heaviest bit of the Flying Flea. At the cost of bending a certain amount of axles, and having to reinforce them, I have attained a useful maximum of solidity and of weight. An elegant solution to the free axle has been found. This part, the guardian of the machine and of the pilot, is beyond criticism.

The wheels are within reach of the hand. That is very convenient to take off, when one is blocked behind a bump or stuck in the soft sand of a seaside resort. Thanks to the low build of the fuselage, thanks to the fact that the heavy masses are concentrated as low, its possible, the center of gravity is at 75 cm above the ground. In addition the machine carries a lot of weight on the tail over eighty pounds so that it is more or less uncapsizable, when you allow for the case with which you can brake it by the front wing, and its enormous tail. This landing gear with its enclosed axle permits you to land in high grass in ordinary fields.

There is one refinement, which is very important, and which I advise you to adopt. That is that of the rudder, fitted with little wheels, in order to ensure that steering on the ground is as accurate and easy as steering in flight, and carried out by the same action. The Flea, which is a sort of secret machine, has to be used on all sorts of grounds. France is much cut up, it is like a vast allotment. You can only rarely find large bits of ground in complete squares; most grounds are longer than they are wide. For a long time my own aerodrome was a strip of old lucerne grass; it was 350 yards long, and 20 yards (Yes! I said 20) broad. The main roads of France, the most beautiful, and best roads in the world, are also excellent carpets for the feet of our animal.

With the rudder connected to wheels, the Flea steers beautifully straight, and can come and go without thought of the wind, and it does not care two pence for a take off cross wind. In 1934 must one ask why all aeroplanes are not fitted with wheels, controlled by the rudder?

SECURITY OF FLIGHT

I have explained the power given by the wing when it is disconnected from the mass of the machine, a power which is seen at the taking-off, in flight, in landing and for braking.

In flight, there is the impossibility of stalling; turns which are necessarily correct; the control column which pulls on the hand, and which, when it controls the direction, can be seen without being

looked at. All this permits, so to speak, of blind flight (flight without visibility), without any instruments except a compass and an airspeed indicator. The machine is very good in bad weather conditions; in short, under all circumstances I can say that the formula of the Flying Flea does away with the risks of flight, and considerably diminishes the risks of the air.

PERFORMANCE

The Flea, at the moment when I am writing this book, has only achieved ten hours of flight. I have told you under what conditions these have been done. Carrying 5 lbs. to the square foot, and 22lbs to the h.p., it has climbed to 1,600 feet in eight minutes by stop watch. Its cruising speed at normal power (15 h.p.) is 65 miles an hour.

When climbing, or when flying slowly, the speed is fifty miles per hour. Under these conditions the power is 10 h.p. It takes off under conditions of no wind in 300 feet, it ranks in 175 feet without any brakes on its wheels. If it had brakes or tail skid, it would roll half as far. What is its ceiling? I have not been able to try it; it has been too cold. We can see that at ground level the throttle lever is only a little more than half open, and this allows us to fly slowly at less than three-fifths of the total h.p. That means a ceiling of perhaps 13,000 feet. Call it 10,000 if you wish. It is quite enough to fly over a lot of clouds. The same reason makes us estimate its L/D as somewhere about eight. I tell you that this ratio has not been one of my deepest cares; I have been preoccupied with other things.

Because I have been seeking a design suitable for the amateur, I have had to simplify each element, assembling them in an easy manner, and reducing the cares of manufacture. The efficiency ratio has just come by itself, and is satisfactory another piece of luck. The whole machine is short and compact, the landing gear has been reduced to two wheels and a few feet of axle tubing; the wings are solid, the bracing limited. The principal resistance is caused by the engine dashboard pilot. That is a resistance which could have been lessened, but still it practically represents the whole thing, and it is concentrated on a short length.

To sum up, heavy as it seems to be, and in spite of the extraordinary visibility from its cockpit, the Flea need not blush at its flying qualities. It is far from being perfect in every way, but I let it go at this; it would take an honorable position in any sporting competition. I leave to amateurs the business of perfecting it, and cleaning up the details. My role is finished for the moment. I have done everything on this machine except aerobatics, which in principle are of no interest either to the air liner or to the private owners' machine. If you wish to arm this machine with machine-guns and start off chasing men, well! that is up to you. It is nothing to do with me if you wish to go and break your own head or someone else's.

Gliders of the Zogling type require launching tackle or a tow-rope. We who are of the school of the kite, have dared to cut the rope! It was a German who launched the Zogling, why should not Mignet launch his own kite? This animal is evidently something; you and I cannot pass it by indifferently. It will excite much unfavorable comment, but it will also make a multitude of firm friends. The Flying Flea is worth more than the Zogling, I am sure of that!!! It is the most simple aeroplane in the world, and it is also the smallest aeroplane in the world.

CHAPTER VI EXPERIMENTS

I had made my machine, my little machine which had not yet been baptized the Flying Flea. A last coat of varnish, and the little bus was ready to take the air. But where? Official grounds were closed to me. Some friends came to my rescue, and this most difficult question was solved. I would camp. The whole of France is nothing more or less than a vast aerodrome for the amateur camper. I was converted to the idea of camping; it is a good and fruitful way to live.

To camp in the winter, under the snow, with fifteen degrees of cold, that is all right for a few days to prove one's sporting qualities, but two weeks of that life makes one dream of the Sahara; two months of it gives one the irresistible desire to grill in the sun and to finish with camping, whatever it may cost.

Polar explorers stay months or years in tents shaken by a blizzard; lion hunters do as much, but under conditions of extreme heat. From where does their energy come this power to face up to the hardest possible conditions of existence? These people have an aim, that is their secret. A single flea can drive me mad, when I have got time to scratch myself, but if suddenly you hear the noise of some accident in the street you rush to the window and gape at it, and forget about all the fleas on earth.

I have camped for 450 nights in three years, through baking summers and the coldest of winters, but I had an object and I did not think about fleas. To camp without an object, when it is too hot or too cold even for that matter when the weather is temperate I really could not do it myself.

I fixed my small machine behind my motorcycle, my wife took her place in the sidecar, and allowed herself to be covered unfortunate one with all sorts of parcels and tents and other things, and there we were on the road. We had some trouble in climbing the hills on this warm day in second gear. I knew something about sleeping out during the war, and at first I was not very anxious to do it again, but now that we have these beautiful small tents, with double roofs which do not drip on you, and ground sheets to keep the damp from your bones, it is another story.

The Flying Flea in its coat of varnish, and with its engine covered up, camped out also, tied down with string, and we enjoyed ourselves. We breathed great gulps of fresh air. If storms came on we were comfortable in our tent; the sun beat down on us and made us healthy; the poisons which accumulate in the town were got rid of with the stars for our roof under the wings!

Camp like me, my friends, when you make your first attempt; you will never find a better method. You will save a lot of time, and you will become better pilots, after having lived holidays so well spent. I need not give you details. Everyone will have friends who will tell them about tents and blankets and cooking pots and shoes, what you should take, and what you should not take. Go and talk to them. You will spend a little money, but it will be much less than you would spend on a holiday taken in any other way.

I will only give you a few hints; if you are alone, cook once a day, in the evening, so as, not to lose time, and eat your food cold next morning. Do not forget to tip any keepers who are about; you will make them friends for life instead of enemies.

Be patient with everybody, particularly with children; do not hesitate to answer their questions. Never say on what day you are going to fly. Keep your camp in order; do not leave paper about. Always ask the permission of the owner of the land before you camp, and show him a photo, if you like, of one of your other camps. He will not refuse you. Do not camp close to a main road but camp near a side road, so that motor cars will not drive across the fields to see you. Clear up before you go, and Nature will do the rest.

The next day I started my tests, and they began badly. My engine seemed stiff: my reduction gear and my propeller were well suited; a great stub of wood burst through the bottom of the fuselage. I made a second propeller and overhauled the engine. I left the ground in a zoom, fell on one side, damaged one side of the fuselage, bounded into the air again, fell on one wing, damaged the other side, and found myself stopped at last somewhat shaken.

The machine was balanced too far aft.

If I had been at an aerodrome, I should have been greeted with the siren which denotes an accident,, the ambulance would have come, and the aerodrome chief would have tackled me what a horror!

At least here in my field, I can break my machine and damage myself if I like in complete liberty.

I returned to my garage. With the aid of plywood, glue and nails, a new fuselage took shape, with new hope. In a month everything was ready again, but the weather was bad. At last a good day arrived. Looking out well for any high ridges, and choosing a good path, I opened the throttle, started to move forward, pulled the control stick towards me quite gently. . . . In a moment I was lying on my back. The petrol was glug-glugging out of the cap of the tank. I loosened my safety belt, and fell on one wing, with my legs in the air.

The machine was balanced too far forward.

After a thousand attempts my old engine gave me at least two minutes of full power before it heated up and stopped.

I used to make many flights in straight lines of 1,000 yards each, and accumulated a few half hours. These experiences were made with my old type of machine, and I never seemed to be able to get it to fly very well. One day I made a nice flight of 800 yards and was getting ready to land. I throttled back, I touched the ground and bounded up to 30 feet, with the engine up in the sky. Remembering that I had done this before, and that somebody had told me what was the remedy open throttle

again I did this. The engine picked up for a moment, and here I was safely down. I did not break it that time. But a few days later I smashed it up in a superb head-over-heels tumble, after diving from thirty feet of height.

On the 10th August, 1933, I put the first nail in the first real Flying Flea. On the 10th September of the same year it took off. Of course, I had several bits and pieces over from the other machines which I had smashed, and I worked ten hours a day. As a matter of fact I lost five days, owing to some difficulty with wing tips, and I consider that I did construct my Flying Flea in one month. The rest is told in my diary:

14th September: my machine is flying very badly, I cannot understand it. There does not seem to be any stability in any direction. The sun has been in my face all day, the grass is long and the wind is blowing crossways. I have been terribly thirsty. My spirit is failing me; I would have been better off in Paris in my cool flat. It is too warm here.

I did two straight flights by leaps and bounds; I flew badly and landed badly. I came back to my camp fed up with everything. My friends! save me from my friends! One old gentleman who waited here, said to me "not bad, not bad, congratulations!." and then went into the details of the kites he had made with bamboo and newspaper. After this somebody else told me about the bicycle race round France. "It is very nice, your little machine," said a little brunette. "Isn't it pretty," and so on, and so on. . . .

15th September: I took off the fabric from the middle of the back wing, cut out three feet of the main spar, joined it together, recovered it, and revarnished it. It works better.

16th September: I tried, again in the evening; the wind had fallen. A friend came to see me from Lille, and in order to photograph My flying 1500 feet above the ground!!!

When I throttle back in order to land, there is a tendency for the tail to drop; the front wing is too high, and there is a tendency to stall. I seemed to glide down very well, but I misjudged my landing, and landed in the road.

I got off today with 1,400 revs. instead of 1,600. That is good.

17th September: It is very warm; there is no wind, no air. I work in a bathing dress. You could not wear anything else.

I lowered the wing by four inches by cutting the tubes which supported it. It glides better now, but I always throttle back too late, and I find myself: landing on the rough ground. I tried its control by pushing my hand to right and to left, which gave me the most extraordinary curves. Landing I let my hand go too soon, and dived into the ground from twenty feet up. The fuselage actually struck the ground as the wheels came up to the full length of the shock absorber, and made a groove. in the ground: both tips of the propeller were broken. I got back to earth after bouncing to thirty feet somehow! The engine was vibrating; I stopped it.

The sun is setting as I pull out my spanner to take off the hub, bringing the screw back to camp. I return with a little spare aircrew; too small as a matter of fact. I bolt it on again, and start the

screw going. Night is falling, but I get back with full throttle, searing a flight of partridges. Honor is saved. What then? Well, everything is going quite well, except for this beastly turning. The balance fore and aft seems to be perfectly correct; the lateral control seems to be too strong, but even then the machine doesn't seem to want to turn; it is too stable.

19th September: I think over my accident of yesterday. It was the same story as last year when I broke my old machine. This time the machine is stronger and has stood up to it. I think out the matter. Each time I had moved my hand too abruptly. I must be gentler with the controls. The days pass by. Sometimes I fly, sometimes I fail, but I accumulate time, and I gain experience. We come to the story of the 8th November. On this day I telegraphed to my wife, "I made my first circuit of twenty minutes at a height of 1,300 feet quite safely. Hurrah!" The day is warm, the wind comes from the east. I wait for the evening. "It is time I went home, I cannot stay here for ever. The cold is coming, it will chase me out. I must risk, something. The machine climbs, turns, it is stable." I was thinking like this all day. At 3 o'clock in the afternoon I started the engine. Shall I make a test flight? I take off towards the east correctly, and pull upon the joystick. Here I am at fifty feet. I can stop if I wish, there is still time. No, I am going on. Without pulling too hard on the stick, I let the machine take its course. Here is the road, the power lines, the canal, the river, some marshes. I cannot get down in that sort of country. With one eye on my airspeed indicator and rev. counter, and listening to the noise of the engine, I do not worry much about the ground. I climb up out of the valley, and come up level with the plateau on either side. The banks fall away below me, and the contours seem to flatten out. I feel myself surrounded with clear green air; the sun is low. I am surely high enough to turn? Let's try it. Stick to the left a little, push a little harder, and suddenly I see the ground apparently straight below me. This startles me a little. I see the village grouped around the clock tower, surrounded by little gardens just below me. "Do not think about empty space you fool." The country moves past me transversely all right. One wing on the horizon, the other high the sky, a turn in a semi-circle and following along the road towards the west, brings me with in sight of Soissons. I feel quite calm. "How strange that I am alone in the machine; no jokes now!"

I suddenly get a little panicky, push on the stick a little, pull it and move it from side to side. My Flying Flea does exactly what I want it to do, and I feel reassured. By how high am I? My altimeter is in the pocket of my shirt; I wonder if I can get it out with my left hand, without moving my right? Gently! Ah! it is done. I am 1,300 feet up! I would not have believed it. I lean out over the empty space. Height in an aeroplane, in a real aeroplane, does not seem anything like height in my little Flying Flea.

My own plain is behind me; the dark square that is my own wood the white spot is my tent. I am up above, with the noise of the engine, and the speed of the wind of my travel. My camp looks very near and far! it seems to me that to come down will be a very complicated affair. I turn again on one wing like a master pilot! It is quite a smart turn! Hello! Too much hand to the left. The Flying Flea comes back on a level keel easily. My wood comes before me, two miles away under my engine. I reduce my speed. I sink under the level of the plateau and seem to be sinking into shadows. Good-bye, bright sky. Although the valley is large, it seems to be in the shade, like a corridor. The last little brown leaves of the poplars are trembling in the light air of the evening; perhaps they are applauding me! The glide goes on. I keep a little engine, because I am still rather short. I give a little more throttle. I come down a little too fast. I throttle off, and settle gently on the ground, almost touching my little wood. Solo for the first time! I have thoroughly deserved it. Until night falls I walk around my

little bus, thinking of my joy, reliving the least details of my flight! The first time in my life that I have really been up in the sky, doing what I like in my own aeroplane! And what a flight! I can hardly believe that I am the author of both. How easy it is to fly it! What a good little engine! Is it all over? I would have liked to go on. That is enough for this time, we must now think about home. But I do not go home.

21st November: A beautiful day without a breath of wind, and the Flying Flea is covered with frost. I hear the sound of an engine, and a large aeroplane comes and lands. It is my friend, Collin, who has come to photograph my flight in the air. We take off. It is a new sensation for me to see this great yellow whale gliding along at my side, at one time covering me with its wing, at another zooming away at a giddy speed. When it dashes past me at about 140 m.p.h. it is rather startling. My friend waggles his rings three times the photographic seance is finished. I go down and land. Collin lands beside me.

"This is the first time," said he, "that I have seen the Flying Flea in free flight! We ought to celebrate it Come and lunch with me at my house."

"With pleasure," I replied, "but my car is not in running condition."

"What do you want with a car?" said he. "It is the Flea which will take you there."

"Do you think so?" "Come along, come along, fill it up and let us go." Soon I am lending behind him at his house, greatly moved to put my wheels on the ground under such circumstances. A bottle and glasses appear, a cork leaps out, the first real journey of the Flying Flea is celebrated in champagne!

1st December: This was to be a duration test. There less a slight wind, and I had an easy take-off .with the motor running beautifully. Holding the control stick with my left hand I wrote notes on a block. Suddenly I got a shock for the petrol was flowing out of the tank in a great stream: the petrol cock had come unsoldered. I stopped the engine and looked at the ground. This is the first time I had had a forced landing in the country. I managed to put the machine down very slowly in the last furrows of a field, and hastened to block up the hole in the tank with my thumb. Some field laborers ran up. "Give me a cork," I cried out to them. I put the petrol cock into my pocket and fixed up the pipe with the cork. In front of me I have a field 400 yards long with a small drain every forty yards. At the end of it there is a curtain of high poplars: on the left there is marshy land planted with little trees. I have been on the floor ten minutes and fifty people are already there; men, women and children. I open the throttle and leap towards the poplars. At the first ditch I pull quickly on the stick and run over it. The second I leap in a similar manner. By the time I reach the third I am in full flight. I let my hand go forward in order to pick up extra speed, and leave the field with a magnificent stunt turn through the opening of the marsh. I make one circuit in thanks for the cork, and go on.

It is very cold. There is a damp sort, of fog, and though I am smothered in clothes I cannot keep warm. I shall have to come down very soon. At 1,300 feet the foggy look disappears, and I find myself in beautiful clear sky. The east wind is below me. cold and full of winter, but here I am in a

south wind, soft and warm, reminding one of better climates. I no longer want to go down. I never wish to be happier.

After flying for an hour, and after a moment of panic when I cannot find Soissons, I land at my camp.

It is still daylight. I feel quite warm now. The mind is going down, and it is quite calm. What a fine evening! Shall I fly a little more? I empty a can of petrol into the tank, take off quickly, make a steep turn of 50 degrees, bank and climb away into the sky. I make a few turns round the pretty little town, and wave my hand to my friends, but now it is time to go back. The earth is grooming cold. On the roads the motor cars have lit their lamps. I leave the sky with regret.

3rd December: It is blowing hard from the north. east, a freezing sort of wind. The sky is empty. Even the birds are not flying. If a lark gets up it settles very quickly again because the wind takes it backwards. This is no flying day for the birds.

Some friends have come to see me, and one of them is a pilot. The gusts are whistling through my little trees, but the ground is dry, and here is a chance to try my wings, perhaps for the last time this year.

I take off in twenty-five yards, and am buffeted about at once. Laterally my machine does not behave any better than an ordinary machine fore and aft, that is another affair! We are flying quite steadily and are not afraid of anything. Ordinary aeroplanes seem to us unsteady, undisciplined things, but you, my little Flying Flea, are like a bird.

The spectators were startled. They looked at one another asking how this adventure would terminate. One of them was a doctor: had he got his bag with him? Another prepared his little car to pick up the pieces. . . .

As for me, I was pretty busy piloting the machine with one eye on the speed indicator and another on the accelerometer. Even in the worst bumps I found that my apparent weight was only one and a half times the normal! That is the kind of safety which the pivoting wing gives.

I am now facing the wind. At 300 feet above the ravine I find myself in the most violent storm with the maximum of turbulence. I make practically no progress. At 1,300 feet I cannot go forward at all. The wind is blowing at 60 miles an hour. It is no good going on. I get up to 1,600 feet in case I can find a less violent wind and turn carefully and soon find myself flying with the wind behind me at 125 miles an hour. My word! that is some going.

In a moment or so I arrive above my camp. I turn and throttle down. At 300 feet above the ground disturbances are very violent, and I have plenty to do to keep control. I am beginning to be a little worried about how I am going to land. One cannot land in such violent gusts as these. I push down my nose a bit. I am going at seventy-five to eighty miles an hour, but am hardly making any progress. The stability seems to be very good, and I find it absolutely perfect fore and aft. The machine does not tire one bit at all, and I do not feel knocked about as I am in an ordinary aeroplane.

The ground gets closer. I rather wish that this was all over. I begin to think I have had enough. I have to open up the engine a bit because I am short, and I carry on for three or four hundred yards hedge hopping. Not once am I lifted up or dropped. I find that with my stick I can avoid all change of altitude; this is the result of the direct control of lift. I land finally, rather foolishly, at the edge of the little wood, and hit the ground with one wheel doing an involuntary turn, which makes me run into the Wood and break a few branches.

My Flying Flea is intact, and I am too. I unbuckle my belt and climb out of the machine with a pleasure which I cannot hide. I am absolutely delighted with this last test. Whatever happens the Flea flies. I shall go back to Paris content.

I have the right to write a back.

This was sport, grand sport indeed, and I repeat that the machine answered so readily to my reflexes that at no moment did I feel myself in any danger or likely to lose control. I am quite sure that I Could not do the same in an ordinary aeroplane(my friend Collin's aeroplane which I have flown for about thirty hours). I heard later that Collin himself was flying on the same day at the same hour, that he broke his tail skid on landing, and said he had had a very rough time.

11th December: By now my machine has ten hours of flying. There is nothing more that I can do here. The cold is driving me out. Last night I slept badly with 15 degrees of frost and a cold in the head. My ink water and oil are "all solid. Outside, everything is white with hoar frost. I collect my tools and my materials, I turn the wings along the body and fasten the machine behind the car. It is all over. The Flea has finished its tests gloriously. It is intact.

Nothing. can happen to me now. Whether I get rebuffs or honors nothing can equal in power and emotion the time which I have Just lived through. Nothing can. wipe out its memory, but for the moment aviation is finished. I am off Good-bye my little wood where I have camped, good-bye!

CHAPTER VII

HOW I BUILT THE FLYING FLEA

If you are able to nail together a packing case You are able to build the Flying Flea.

WHAT is an aeroplane?

-A light body, pulled forward by a propeller, securely suspended under a lifting surface, which it trails along.

-A chain, of which all the links must be equally strong. If one of the links gives way, the whole arrangement ceases to fly.

-An agglomeration of simple elements which gives it a complicated appearance. An ordinary structure without any precise adjustment, in which one insists that nothing should deform.

This fuselage which I am making by sticking together small pieces of wood which I prepare, plane down and nail. What will be its destiny? What clouds, What valleys will it fly over? Towards what district will I be drawn, seated on its cushion, tied to its seat with a belt? It possesses, latent in it, a whole programme, a whole life of adventure.

But lately a piece of wood, now it is beginning to take shape; this destiny which is still unknown to me is there, in front of me, under my hand . . . invisible, while I take on its mastership; I the author of a life of which I do not know what will be the manifestations and to which my body will be tied by an intimacy sometimes joyous . . . sometimes serious and severe!

A dream? no, a reality!

Imagination? no, adventures lived!

The material once prepared lives. It will live more objectively under the influence of the engine. It will grow old through usage, it will become run in. The flanks of the fuselage smeared "with oil, blackened by the exhaust fumes, greened by the grass . . . the inside of the cabin dirty, worn, scratched by the shoes, blackened behind the back, drilled with holes which have become useless, the remaining marks of my experiments. . . . Flight, adventures, all the various jobs to which it has been put . . . quite an accumulated past comes from this lightweight box. Not everybody has a life so filled! Go and examine closely at the aerodrome an old machine. Do you not find yourself under the spell which exudes from its decrepitude?

Thus then a type of friendliness, I war, going to say love, makes you think that the materials chosen for the special construction that you are going to undertake have to be touched with clean hands. Have respect for the material: do not use it. Wood is not only part of a tree; it is a sinew, a nerve. Examine it closely to see whether it is in good condition. See to smoothness for the exterior. Attend to detail for the interior. Finish off the parts carefully; round off the rough angles; remove the dirt. By doing so spectators will congratulate you on your workmanship.

The amateur is like a sailor; he knows a little of everything. He is universal. It is not a case of a whole lot of mathematics being indispensable to him: his ability to search about for a solution suffices to save delicate situations. He possesses above all things, an enormous amount of common

sense. For that, there is no school. A little money, plenty of common sense and an amateur who can tighten up a nut properly will succeed in making his machine.

As the result of observation and the work of an amateur's life, the procedure that I give here is meant for amateurs. I intentionally adopt simple explanations so as to avoid professional language which might frighten the amateur or would waste his time and his patience uselessly. Some will find this procedure rudimentary. "Do this, do that," they will say! Flee from their advice as from a plague!

Avoid people who have a marvelous secret. I do not give you the choice of several models of machines: I give you my own, the one which has ten hours of flight, which I have amply experimented on, the one which, while I am talking to you in this book, is there, by the side of me, all ready to take off if I start up the propeller.

You want to fly as I do? Copy it exactly without changing anything.

Do not follow your own inclinations. Keep for later on any personal improvements, until you also have ten hours of flight. You will then judge your inventions from quite a different angle, believe me.

Prudence

A professional man will criticize the design: "Much too strong, therefore too heavy!" The Flea weighs 220 pounds. It is light. It might weigh less but it has been so simplified that it could not weigh much less. Lighten something of your own accord? You want to commit suicide without a doubt!

Leave such frailties to other men. Your friends the, amateurs, will not laugh at our rough methods! they know all about it.

Everything which is to fly must, of necessity, be light. Agreed.

One day, when you are going to repaint your plane, you will dismantle it. Out of curiosity you will weigh the pieces . . . ten, twelve pounds too heavy? You have added things in the course of your last flights!

From that day on the obsession possesses you, holds you . . . you have a horror of weight. It becomes a mania!

You weigh, you streamline, you lighten All of a sudden, a sense of reality comes back to you: "But am I mad! My machine has perhaps become frail! I am losing my head. I have forgotten everything."

And now you find yourself between the hammer and the anvil, between the file and the material. Too heavy too light. Dilemma. To lighten a machine does not only mean to scrape all the material which is not required by the adopted coefficient of security. It is not enough to transform a panel of 3-ply into a skimmer, nor to chamfer the angle of all squared pieces: this is called "scraping away the grammes" with a nail file.

Rational lightening is obtained through a judicious conception in centralizing the strains, in avoiding complications, by diminishing the number of important parts. In this way one economizes tens of pounds. These few pieces can then be reinforced: they only become a few ounces heavier.

THE TWO-SEATER

You leave not yet built. You are interested in aviation from a certain angle. You think to yourself: "I will make a 2-seater straight away." Oh, poor amateur! poor dreamer! How many times have I not been written to concerning this devilish 2-seater . . . ! Everyone dreams of taking out their little girl friend before they know whether they can raise themselves from the daisies!

The amateur's aviation is a solitary sport. Like horse racing. The jockey weighing 100 pounds will always beat the fat one.

Aviation is a special sport. What is heavier than the air will always need to be light.

Watch the big touring plane with two or three engines preparing for a journey. As on a free balloon everyone cuts down his luggage: it is so easy to accumulate 100 useless pounds! How many go without parachutes in order to carry an extra four gallons of petrol. Aviation is above all things a problem of weight. A 2-seater. You'll never fly except alone.

A 2-seater will necessitate thirty-five to forty h.p., a double load of petrol, considerable expense . . . the other type of aviation. . . . You will not find an engine. You are tied down to the single seater, you cannot get away from it.

I will not stand having a 2-seater for an amateur mentioned to me. I shall not reply.

You are going to construct a flying machine. First of all, you will get it off the ground. It is easy. Then you will pilot it over the fields a few feet up. It is a great joy. And then you rise. Far off hills will rise up from behind the horizon you are familiar with. The top of a tree passes underneath your wheels. The spire of the villare church is lower than your horizon. There is plenty of space underneath your wheels!

Well . . . supposing your wings broke at this moment?

Do you not shudder a little in advance? I did; I no longer do. Not because I have got used to danger . . . but because I have super abundantly reinforced the points which caused me anxiety. This shudder you will avoid if you follow out exactly the instructions in my book. Some correspondents have Sometimes asked me for full size drawings on a large scale, blue prints, such as one gets in the workshop. What is the use, if, on a small scale, all the indications are given?

If you cannot read them, interpret them, it must be that you are a fool. Do not undertake the construction: you will hurt yourself.

MATERIALS

You will search uselessly for raw "aeronautical" materials. I chose a wood which can be found in any joiner's shop the fir from which are made our furniture and our roof beams. The dimensions used are in accordance with its coefficient of strength. If you find American wood, spruce, Oregon, all the better. The same weight, greater strength . . . do not alter the dimensions: you would only economize a few ounces. . . .

As regards the choice of metal, I put myself in the most likely case of the amateur in a village. I chose mild sheet steel because it is easy to drill, can be filed, and can be bent without any special precautions. I rigorously reject the use of aluminum (more or less hardened) in the vital parts, in the stays for the wings.

It is a metal which appears to be strong and lurks waiting for the occasion to trick your watchfulness. Aluminum is treacherous: it is hardened earth! There is only one metal for the amateur: sheet, tubes, rods plain or screwed, nuts and bolts and are made of mild steel as found in all ironmonger's shops.

The mild sheet fastened to wood by small bolts will stand up indefinitely against vibration and resonance.

Long live steel! Long live wood!

ACCESSIBILITY

The Flying Flea is of simple conception.

The most elementary prudence dictates that one should only confide one's life to simple mechanism simple and easy to check.

A bolt, a nut, a split pin, then they are accessible can easily be inspected. They will not refuse to do their job. If hidden, the most firmly fixed part will end by having some "play," by coming detached. . . . An explanation will possibly be found . . . but it will be too late. It is necessary that all the mechanism in an aeroplane, should be visible, accessible, easy to check, easy to take down. Then it will last.

If not, it will kill you. This is the law of Nature.

I have not put a casing over my engine; I have placed all my controls on the exterior; the stays are within reach of my hand. The fuselage is an empty box. It is all easy to keep in order.

CONTROL

I do not know the future, nor do you. Anything may happen, even favors from the Authorities.

Perhaps one day your Flea will be given a certificate of airworthiness by official authorities.

Beware! Perhaps the constructional technique of this book will be accepted . . . as a serious basis of amateurish endeavor. Anything may happen, I tell you! If you do not follow scrupulously my directions., you run a risk of being refused

THE RIGHT TO FLY.

I beg the official controller who will examine your machine (which will not yet be covered with fabric, of course) to be extremely strict regarding the correct erection of the stays of the pivot of the wing, of the bends in the sheet steel, regarding the choice of material, of the structure of the wood used with no knots and the grain almost straight, etc. . . .

He should refuse categorically all permission to fly to those stubborn ones who have refused to follow out the indications of the book. To examine the Flea is so easy that no important defect can be passed over, and the position of its center of gravity is not important within a few centimeters: the examiner, after close examination of the machine, can easily discharge his responsibility. Fruit of a long experience

the Flying Flea cannot break in the air.

THE PATENT POSITION

An inventor has the right to the child of his brain. Others cannot copy it without his consent; more correctly one may copy an invention for one's own use but may not do so for any purpose of gain. There are important patents on the Flying Flea which protect it in every country of the world. It is of no importance. You, the reader of this book, have the right to build and to fly it, as much as you please. You have a right to make a present of it to a friend, but not to exchange it for a sum of money or for some object having a commercial value. You must not sell it. If you construct a 2-setae, you must not charge your passenger nor make him pay you for reaching him to pilot it. In a word, you are not allowed to obtain any pecuniary benefit from it under any circumstances whatever: public demonstration, paid services, commerce, industry, etc.

THE AUTHOR'S RESPONSIBILITY

The Flying Flea cannot break in the air. This refers to its normal employment as a vehicle. With a motor car, with a bicycle, in a boat, on a horse, etc., there are two ways of making a journey or of indulging in sport, prudently . . . and imprudently.

Human foolishness when it lets itself go knows no age, no luck, no race, no limit. Everyone does as he likes, but each one pays for the consequences of his acts. If you are prudent as I am; if, like sailors and the aviators of certain companies who have rightly understood the possibilities of their vessels, you fly in atmospheric conditions which are favorable, nothing will ever go wrong with you. There is infinitely less risk than by road. Under these conditions, I take the moral responsibility of it. On my conscience, I cannot let you be imprudent. I have flown. My machine is strong. You can do the same.

I consider that I have foreseen everything, said everything, so that no trouble can arise.

Many clubs, taken with the simplicity of Gliders for training, have wanted for economy and for the love of sport to build for themselves their machines. Apparent simplicity. Who was to know, in advance, that such and such a very curved profile had a certain diving movement which might, all of a sudden, break the wings? That piano wire, however slightly stressed, constituted an insufficient bracing?

The particular design of the living Flea and its method of construction place it in quite a different class. I know what I am doing. I know what it can do. I leave to the future the task of showing that it is, above all existing aeroplanes, and by a long way, the least suicidal.

But I shall have no regrets, no sorrows, no emotions, if I learn that you have hurt yourself by committing an imprudence. That is none of my concern

FLYING

But you are raised. Analyzing your own ideas, you say to yourself: "Mignet flies. I want to imitate him and very soon fly better myself. So as not to lose time, I will copy exactly his machine, so as to find myself on exactly the same level. And after that we shall see who is the better, my friend!"

To conquer weight, to disport oneself in three dimensions, is the strange fascination of this marvelous science.

Long live the sport of the air!

The smallest results indicate the man. Each one can show his value, each produce a spark. A sensational record, round the world without a stop, cannot detract from the merit of the beginner who, his machine just finished, succeeds in raising it from the ground for two seconds. It is he who has made it. He who has piloted it. It is to him, to his skillful hands, to his look bright with pleasure, that all the success is due!

Long live the sport of the air!

Your "baby" is no longer a simple framework covered with canvas and stretched with strings. It is a latent power.

They will shine, polished, your brass turnbuckles . . . you will fondle your large propeller which smells so well of varnish . . . you will polish your engine with the deep fins, a thorough red of modern mechanics, whose heart will beat to your orders, suddenly communicating to the machine the personality of a living thing endeared with character, which your reactions must obey. It is your

child and your master. The familiar machine that you look after like yourself, that you love passionately, more than you love a watch or a camera, is an old comrade with you in adventures.

Empty dreams? Vague ambitions?

No! You are going to have a great time! You are going to learn to drive an engine otherwise than by the throttle: you will know about jets, sparking plugs, the chemistry of combustion, revolution indicators, etc. . . .

And you are really going to fly: your engine, simple auxiliary, is going to take you, without letting you down, under its shining wing. You are going to live the "life of the air," as long as you like, to saturation. Perhaps even, encountering some eagles in flight, will you try to fly like them, the engine stopped, and you will learn to make use of air turbulence? . . .

A tremendous future, with undreamed of consequences of which you will perhaps become the forerunner . . . there are the joys in perspective which are going to brighten your eyes!

Long live the sport of the air! ! !

CHAPTER VIII

MATERIALS

Translators' note.

This chapter has obviously to be written as an English version rather than a literal translation of M. Mignet's chapter.

Since metric measurements are kept throughout the book they are retained here except in so far as English "sizes" have to be given for ordering purposes. (See also appendix for conversion tables.)

Constructors are particularly cautioned regarding the drilling of Holes in wood work and fittings. These must plainly be drilled to suit the British. sizes in bolts and nuts available, and, in this particular, the text and drawings must be used as a guide and not for absolute diameters.

Materials and assistance may be obtained from many other sources than those quoted: the names given are those who have offered to help or with whom the translators have had experience.

GENERAL

Materials should be of first grade quality, but need not be special aviation materials, nor A.I.D. inspected. For example, steel tubing, bolts and nuts, and sheet steel for fittings are of good quality commercial mild steel, and not special high tensile aviation specifications.

Do not, however, buy cheap stuff.

PLYWOOD

Birch or other good plywood of "superior" or "aviation" quality.

6 sheets 6 feet x 3 feet 3 mm. thick (grain running the short way).

4 sheets 6 feet x 3 feet 1-5 mm. thick

The Aeronautical & Panel Plywood Co. Ltd., Messrs. Mallinson & Son Ltd., Messrs. Venesta Ltd.
(for addresses see below).

LATHS

Good quality spruce, straight grained, free from knots or shakes, capable of being twisted and bent, breaks with long fibers. You require:

6 lengths of 5 meters 15 mm. x 60 mm.

(or 10 lengths of 3 meters 20 cm., 15 mm. x 60 mm.)

10 lengths of 4 meters 20 mm. x 20 mm.

50 lengths of 3 meters 6 mm. x 12 mm.

These can be obtained, sawed and planed to size from:

Messrs. Louis Bamberger & Sons,

Mr. G.A. Puttnam, (c/o Messrs. E. G. Perman & Co.)

The R.E.A.L. Carriage Works Ltd.

LINEN FABRIC

Only, aviation materials are suitable. The linen fabric as used for full-sized aeroplanes is rather heavy, and strong covering material as used for gliders is approved. This is usually a strong nainsook material at about 10s. Per piece of 12 yards. Cheaper stuff than this is likely to be low in strength.

You require 36 yds. fabric 38 in. wide.

100 yds. notched strip about 2 in. wide.

Messrs. Stevenson & Son,

Messrs. Woods, Sons & Co., (Nainsook No. 200 or higher).

Messrs. Abbott-Baynes Sailplanes

Messrs. Aircraft Materials Ltd.

Messrs. B.A.C. (1935) Ltd.

British Light Aircraft Ltd.

DOPE

Clear glider dope is the cheapest: it should be suitable for use in an unheated shop. You need about 4 gallons. Messrs. Cellon Ltd., John Hall & Sons (Bristol and London) Ltd. (or any of the last four names given under "fabric" above).

WHEELS AND TIRES

These present for the moment some difficulty. Mignet insists on large sections for example 450 x 100 medium pressure. Normal aeroplane wheels and tyres are very expensive.

Try Messrs. Coley & Atkinson Ltd.

Messrs. Isaac Robson & Co. Ltd.

W. Birchall, Esq., c/o Messrs. A. Broughton & Sons.

R. Tomsett.

or the last four names given under "fabric," Or write to the Air League of the British Empire, who have arranged to supply wheels and tyres specially designed for the Flea by the Dunlop Rubber Co.

METAL WORK

(a) Tubing drawn (not welded or jointed) of mild steel suitable for welding.

MIGNET'S SPECIFICATION BRITISH EQUIVALENT

4 meters in 13x 10 mm 5/8 in. 16 gauge

2 meters in 16 x 20mm 3/4 in 14 gauge

2 meters in 17x 20mm 3/4 in 16 gauge

2 meters in 21 x 24mm 15/16 in 16 gauge

0.5 meters in 24 x 27mm 1 1/16 in 16 gauge

1.2 meters in 31 x 35mm 1 3/8 in 14 gauge

1.2 meters in 36 x 40mm 1 9/16 in 14 gauge

0.2 meters in 40 x 44mm 1 3/4 in 14 gauge

also tow bar if you wish

1.8 meters 31 X 3 5 mm. 1 3/8 in. 14 gauge

If the exact sizes are unobtainable take the next larger, e.g. for 13/16 substitute 7/8 inch.

Messrs. Accles & Pollock Ltd., can supply exact millimeter sizes to order, but the cost is naturally more. Messrs. Aircraft Materials Ltd., or any good iron. monger should be able to supply, e.g. Messrs. Farmer Bros. & Co.

MILD STEEL SHEET

You require

2 mm. or 14 gauge (about 3 sq. feet)

1.5mm or 16 gauge

1.0mm or 19 gauge small quantities as required.

.6mm or 24 gauge

Messrs. Aircraft Materials Ltd.,

Messrs. Isaac Robson & Co. Ltd. or any good ironmonger such as Messrs. Farmer Bros. & Co.

DRAWN RODS, SCREWED RODS, BOLTS AND NUTS

You will need a total of about 2 meters of mild steel drawn rod in

4 mm., 6 mm., 8 mm. and 10 mm. sizes.

or 3/16 in. 1/4 in. 5/16 in. 3/8 in. (or preferably 7/16, in.)

also about 3 meters of mild steel screwed rod in

4 mm., 5 mm. and 10 mm. sizes with nuts.

or 3/16 in. 1/4 in. 3/8 in. (or preferably 7/16 in.)

also 50 bolts of 5 x 40 mm.

or 2 BA x 1.6 in.

30 bolts of 5 x 60 mm.

or 2 BA X 2.4 in.

20 bolts of 6 x 40 mm.

or 1/4 BSF x 1.6 in.

with their nuts and a large quantity of spare hexagon nuts particularly in 4 mm. size (for the screwed rod) and 5 mm. for the bolts a lot of nuts get lost. You will want about 200 of each of the above popular sizes and 20 lock nuts for the 10 mm. screwed rod.

In case of doubt take nearest size above the millimeter measurements.

Messrs. Aircraft Materials Ltd. or any good ironmonger such as Messrs. Farmer Bros & Co.

AIRCRAFT STEEL CABLE

Extra flexible.

10 meters in 4.5 mm. for wing bracing . with 20

or 25 cwt.

thimbles and 20 attachments for ends.

15 meters in 2.4 mm. for wing controls with 15
or 10 cwt.

thimbles and 15 attachments for ends. 10 metros of 5 cwt. for rudder control with 5 thimbles and 5 attachments for ends. Turnbuckles for same as directed in book. NO GALVANIZED CABLE. Your life is at stake.

Messrs. Aircraft Materials Ltd., Messrs. Coley. & Atkinson Ltd., Messrs. Woods, Sons & Co.

GLUE

Use case in glue which is used cold and has marvelous adhesive and weathering qualities.

It can be obtained from Messrs. Hardan & Co.

SHOCK ABSORBER CORD

You require about 5 meters of 12 mm. diameter (1/2 inch) which should start to "give" at about 35 lbs. pull. It can be obtained from Messrs. Coley & Atkinson Ltd.

MISCELLANEOUS

In addition you require an amount of piano wire, screws, nails, copper tacks for fabric covering, etc., which can always be bought locally as required. Use thin steel brads about 20 gauge for 3 mm. ply and thinner still for the 1.5 mm.

ENGINES

The engines which are nearest completion for the Flea in June, 1935, are:
Carden 4 cylinder water cooled (converted Ford). For particulars apply: Sir John Carden, c/o Abbott Baynes Sailplanes.

Douglas 750 co. horizontal air-cooled 4-stroke twin. For particulars apply: Messrs. Aero Engines Ltd., Kingswood, Bristol.

Scott 2 stroke air-cooled inverted twin. For particulars apply: Scott Motor Cycle Co.

AIRSCREWS

The Airscrew Company can supply, if particulars are given regarding engine, h.p., revs., gear (if any), speed and weight of aeroplane.

Airscrews are not hard to make if the book is followed.

ASSISTANCE

The following who have had experience in building a Flying Flea or are otherwise qualified to assist are very willing to help amateur builders. Mr. Oliver Rorke knows all the details of the Flea and will help amateurs in or near London for a small fee.

Mr. T. B. Wood and Mr. F.H. Richards will supply parts to fit (particularly metal fittings).

Messrs. Aircraft Materials Ltd. can supply almost anything listed.

The West Malling Aviation Co., British Light Aircraft, Ltd., Abbott-Baynes Sailplanes, F. Hills & sons Ltd. and Sidney Lipert will quote for completed or semi-finished parts.

The Air League of the British Empire (The Pou Club) will help in every difficulty.

COST

Got several quotations; prices vary much.

Careful buying should give the constructor a list of materials for about 25 francs, excluding engine and proprietary articles.

ADDRESSES

The Aeronautical & Panel Plywood Co. Ltd., 218-226 Kingsland Road, London, E.2.

Messrs. W. Mallinson & Son Ltd., 130 Hackney Road, London, E.C.2.

Messrs. Venesta Ltd., Vintry House, Queen Street Place, London, E.C.4.

Messrs. Louis Damberger & Sons, 27 Finsbury Square, London, E.C.2.

Mr. G.A. Puttnam, c/o Messrs. E.G. Perman & Co.

Red Dragon Studio, 24 Brownlow Mews, Gray's Inn Road, London, W.C.1.

The R.E.A.L. Carriage Works, Ltd., Popes Lane, Ealing, London, W.5.

Messrs. Stevenson & Son, Dungannon, Northern Ireland.

Messrs. Woods, Sons & Co., 6 Milk Street, London, E.C.2.

Messrs. Abbott-Baynes Sailplanes, Farnham, Surrey.

Messrs. Aircraft Materials Ltd., Midland Road, London, N.W.1.

Messrs. B.A.C. (1935) Ltd., London Airpark, Feltham, Middlesex.

Messrs. Aero Engines, Ltd., Kingswood, Bristol.

W. Birchall, Esq., c/o Messrs. A. Broughton & Sons, St. Helens, Lanes.

British Light Aircraft Ltd., Luton Aerodrome, Barton Beds.

Messrs. Cillon Ltd., Kingston-on-Thames, Surrey.

Messrs. R. J. Coley & Atkinson Ltd., Ordnance Works,

Queen Elizabeth Road, Kingston-on-Thames, Surrey.

Messrs. Dunlop Rubber Co. Ltd., Fort Dunlop, Erdington, Birmingham.

Messrs. Isaac Robson & Co. Ltd., Lilac Works, Regent Street, Leeds, 2.

Messrs. Accles & Pollock Ltd., Oldbury, Birmingham.

Messrs. Farmer Bros. & Co. Ltd. 164 & 319 Fulham Road, London, S.W.10.

Messrs. Hardan & Co., Brook Works, Cambridge Gardens, North Circular Road, London, N.13.

T. B. Wood, Esq., 12 St. John's Wood Road, London, N.W.8.

Oliver Rorke, Esq., 104 Fulham Road, London, S.W.3. The Airscrew Co. Ltd., Weybridge, Surrey.

The Scott Motorcycle Company, Shipley, Yorks.

West Malling Aviation, Nr. Maidstone, Kent.

F. H. Richards, Esq., 59 Surbiton Road, Kingston-on-Thames, Surrey.

F. Hills and Sons, Ltd., Trafford Park, Manchester. Sidney Lipert, Esq., c/o Newway, Ltd., 11 Hester road, London, N.18.

R. Tomsett, Esq., 39 Bartholomew Close, London, E.C.1.

Air League of the British Empire, 19 Berkeley Street, London, W.1.

John Hall & Son (Bristol and London) Ltd., Broadmead Bristol and Pancras Road, London, N.W.1.

CHAPTER IX TO WORK

The amateur is an enthusiast, an artist who obeys his impulses. The amateur wishes to get on with his wings. He would glue the feathers to the egg before the chicken comes out in order to go faster. He would like to start by making the wings! No, he must follow the logical order.

First, . THE FUSELAGE

Constructive Principles. The fuselage is constructed like a packing case. But since the plywood cannot be nailed on to itself, one has to interpose a lath of spruce in the angles as a means of receiving the nails, and these laths are glued over a large area on each surface. In this way, the sides of the plywood are united to each other, not by nails, which is not a solid form of construction, but by plenty of glue, which makes a sort of welded construction of wood.

These laths are the concentration of the total resistance of the plywood, and allow metalwork to be fixed to the angles of the box in places where plywood would only present a local and feeble resistance. These angles are nodes, or strong points, which are more or less irreducible in number and are firm bases for attachments.

The lathe at the rear end of the box prolong its solidity to the rear, and form a very strong triangulated pyramidal construction. At the risk of being a bit heavy, the fuselage will be constructed in plywood 3 mm. thick. It will not deteriorate.

Preparing the Glue. We make the glue ready for work in advance; for four hours in summer and for a whole day in winter, the powdered glue and water are mixed in equal volumes, not heaped up but measured exactly. (Measure them in glass tribes like chemists use.) Spoonfuls? No, they are not exact enough. Stir the glue with a wooden spatula. The mixture begins to thicken. In five minutes there is smell of ammonia. The mixture settles down into smooth viscous paste about the consistency of thick oil. You do not need a brush. Glue dissolves hairs. The wooden spatula is quite sufficient, supplemented by your fingers.

The Wood. before you start to use it, test your wood. It must be sound. It must not have any green color, reminding you of worm eaten stuff. When you plane it, it should smell strongly of resin. Its grain, twisted like string, should resist your pull.

Each lath, each strip of wood, carefully chosen, is pinched in the vice at one end, and twisted lightly in the direction of its length. It ought not to break or crack. Examine it closely. The grain should be straight or very slightly slanting. Throw away any piece which has knots and/or splits in it.

THE SIDES OF THE BODY

Draw out on a piece of plywood 3 mm. thick the first side, following the dimensions given in Fig. 12. The run of the grain will follow approximately arrow f, and the work should be laid out in the order given:

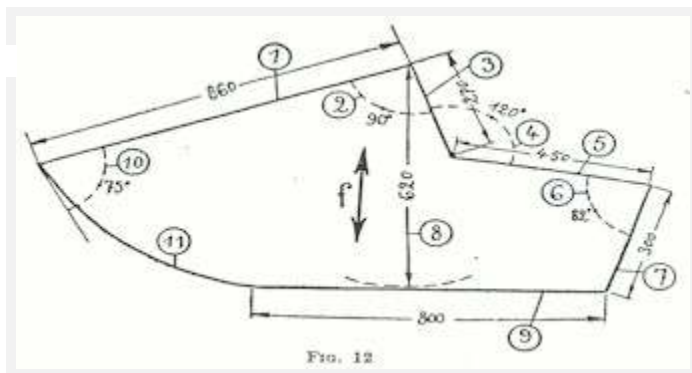


FIG. 12

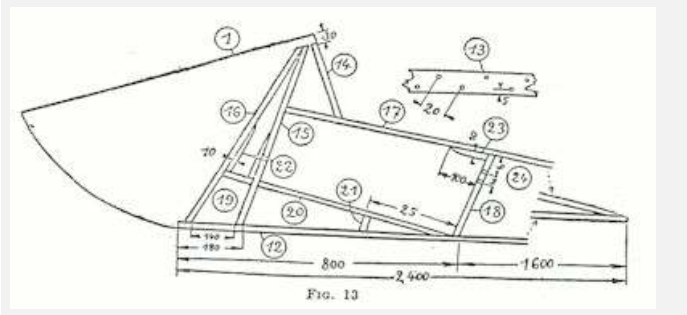
1, 2, 3, etc. All the dimensions are given in millimeters.

Mark out the angles with a protractor. Cut out two sides exactly similar, with a fine saw. One lath 20 x 20, and 2 m. 40 cm. long, is nailed and glued at 12 (Fig. 13). It extends beyond the body towards the rear for 1.6 meters. In order to glue it, proceed as follows:

Spread the glue on 800 mm. of the lath in such a way that after a minute the face of the wood is shining uniformly, without any blank spaces. One nail at each end will keep it steady, and then you nail it in a zigzag approximately every 20 mm. (see Fig. 13). After nailing it the glue will ooze out along the edge. You can smooth it off when it is dry.

Proceed, then, in the same manner, with laths 20 x 20: 14, 15, 16, as you see, leave 30 mm. spare along edge No. 1.

Then the lath 17 supported on 15 and beveled at the other end to fit on 12, which is straight from end to end.

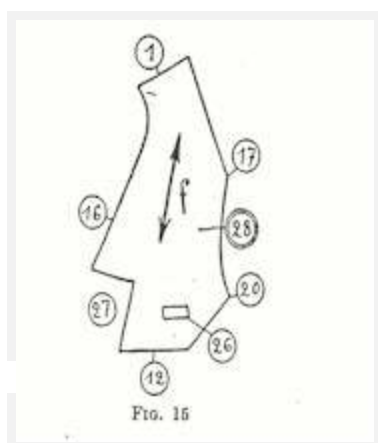
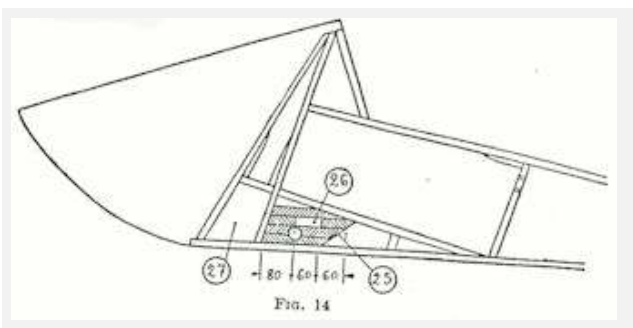


Then 18, 19, 20, 21 and the stops 22 and 23. Note: The lath 18, before it is put in place, should be pierced with two holes 24 at a distance of 40 mm. These will receive, later on, the anchorage's in screwed rod of 5 mm. of the harness. Take care that there is no empty space at the end of each lath.

Make the fillings 25 (Fig. 14) with the ends of laths, keeping the empty space 26 which measures 20 X 60. with the point of a knife, cut out the plywood sides opposite this empty space, where we will put later on the pulley which takes the rudder cables. Cut out also the quadrilateral 27 (110 X 160 at its smallest dimension), through which the axle will pass.

Cover all this assemblage with the panel 28 (Fig. 15) in 3 mm. plywood.

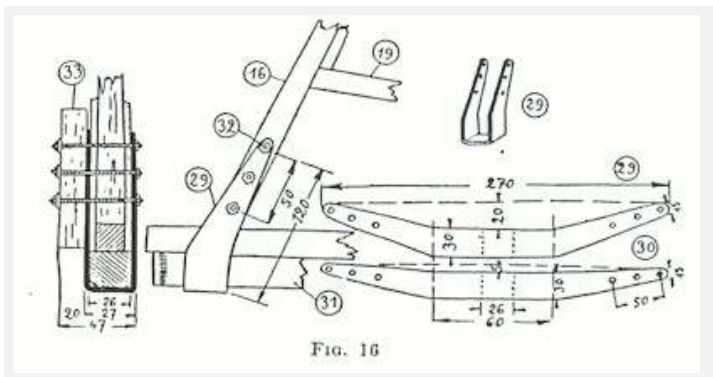
Prepare the other side exactly the same as the first, but in the contrary sense.



It is well understood, I hope, that everywhere where wood touches wood there is glutting/nailing.

From a piece of mild steel 1 mm. thickness cut with clears two strips 29, 30, which, when folded, will clasp simply by gluing under the feet 15 and 16 a skid 31 (Fig. 16) in hard wood, such as oak, walnut or beech, in 20 X 26 x 230. The holes in these straps will only be drilled beforehand on one side. The other' side will be drilled when, after it is in place and solidly fixed by a binding or by a hand vice on the longeron 12, you pierce holes for the bolts 32.

These bolts 32, in screwed rod 5 x 60, will fix as well the short strips 33 in 20 x 20 material which are inside the fuselage. The drawing No. 17 gives the appearance of the assemblage completed. The skid and the straps are designed to reinforce the, longeron 12 when the axle strikes it after jolts. The block 34 in hard wood 10 x 26 x 50 is glued and screwed on the skid at equal distance from the straps, to prevent the elastic shock absorber of the axle from slipping.



Glue the blocks 35, 36, 37 this last one made of hard wood for bolting on later the metalwork for the wing bracing wires. The lath which serves, as the reinforcement 38 is of 20 x 20, at point 39, and gets progressively thinner towards, its ends.

THE JOINING OF THE SIDES

The two sides now have to be joined by the back of the pilot's seat 40 made of plywood 3 mm. as is shown on drawing No. 18. The holes 41, 42, reinforced with circles of plywood, give access to the luggage compartment. The holes and the plywood circles can be cut quite easily with a carpenter's compass, of which one arm

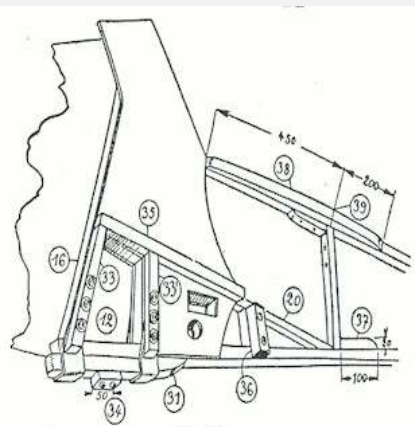


FIG. 17

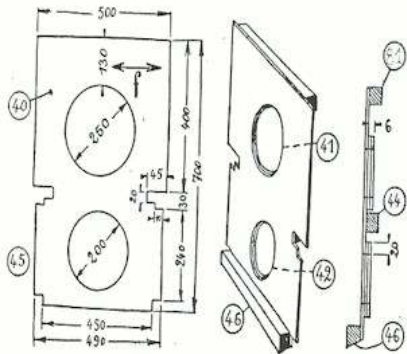
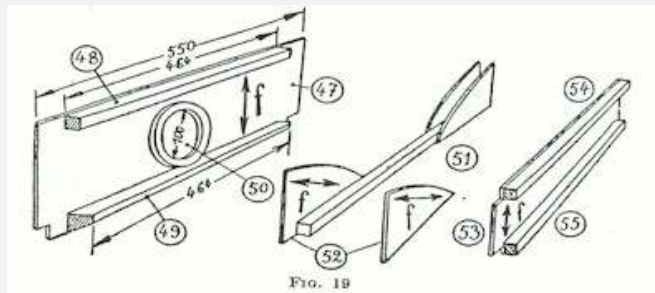


FIG. 18

has been ground to a knife edge. Any ironmonger's shop will provide it.

On the panel 40 you should only place the bar 44 in 20 x 20 x 410 and nail the sides 45 in front of the laths 18. Then put on the cross piece 46, making its edge beveled and level with the underneath of the longerons 12.

The short strips in front 33 m, U then be joined by the panel 47 (Fig. 19) out out in such a way that the crossbar 48 fits on to the block 35, and its crossbar 49



on to the lower end of the short strips 33; thus, the crossbar and the ends of the short strips all come level with the longerons 12. The height of the panel 47 will be decided on the spot. Do not forget the hole 50 reinforced with a circle of plywood. File away anything which could obstruct the straps 29.

The short strips in rear 33 are also joined at their lower ends by the slat 51 and double gussets 52. In the same way, the short strips 36 are united by the panel 53 with the crossbars 54 and 55.

The slats 46, 20, 35, 48 and 54, are all on the same level, and serve to support the plank which forms the seat 56, of which the underneath view is shown in Fig. 20. This seat plank you will decide on the spot with a piece of cardboard, in order not to out to waste your 3-ply. This panel is only

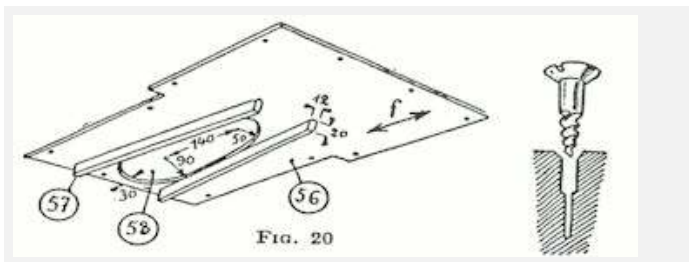
fixed by 12 screws with round heads 4 x 15. It is double; that is to say, the thickness of 6 mm. glued together under weights. There is no point in nailing it together.

Two strips 57 reinforce between the crossbars 48 and 54 the edges to the central hole 58 in which the joystick works. At each end of these reinforcing strips use a wood screw with a washer.

Screws. Before driving the wood screw into place, drill the wood with a hole, of which the diameter will be two-thirds of the smooth shank of the screw, which is matched to enter the hole. Before screwing it home, rub the screw with beeswax.

THE FRONT POINT

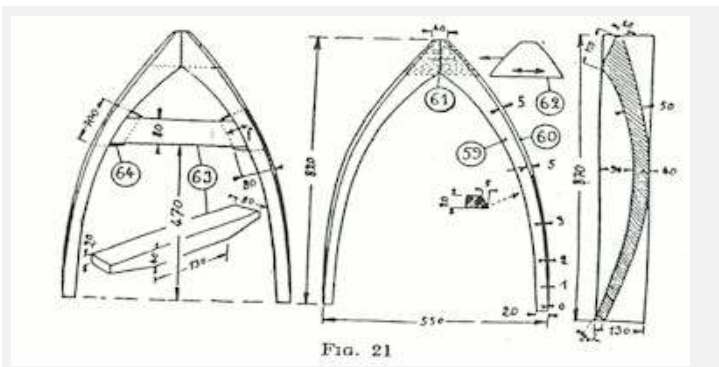
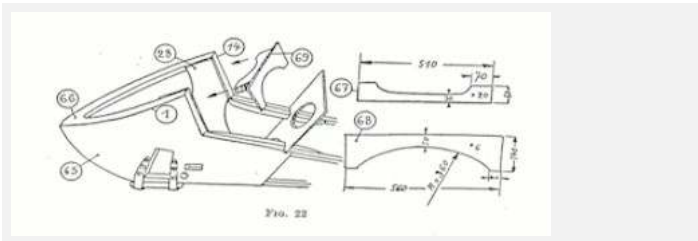
Now we have got to see about drawing the two points of the sides together. The lyre-shaped piece of wood 59 will be cut out with a saw from a plank



of 20 mm. of hard wood, following the drawing given in Fig. 21. Because of its sloping position to the fuselage, it will be necessary to bevel off its outside faces 60, in order to diminish the upper face according to the progressive figures indicated, 0, 1, 2, 3, 5, 5. The arms of this piece of wood will be separated to a distance of 550 mm. by adjusting the flat faces 61, and they will be joined underneath by a triangle of plywood 62, which is glued to them; and, again in the middle by the plank 63 of hard wood of 40 mm. thinned down at the ends to 20 mm. well-fitted and held from underneath by the gussets 64, which are 6 mm. thick. All this is done simply by gluing. This plank, later on reinforced by bolted metalwork, will support the motor.

Beveling, adjusting, and fitting will be commenced with a plane and finished off with a large bastard half round file a metal file bought and kept for this purpose, This file will be used only on wood. It is better than a wood rasp which cuts out the grain, and after the glue is dry, it eats into the wood just as well as a rasp, even if it hits up against some nails. The rasp or the plane would very soon be damaged if it did the same thing.

Enclose the two arms of the lyre between the bits of plywood, 1 and 28 (Fig. 22) gluing them together and nailing it all in such a way that the two sides 65, when drawn together, go a little bit beyond the point 66. Nail the plywood carefully all along the edge of the arms with one nail every 10 mm. Cut off the edges which go beyond the end of the lyre, and plane off the amount which extends above it. (This has been allowed for in Fig. 13 by allowing 30 min. instead of 20.) You now have a smooth joint which allows the whole lyre to be covered by a triangular sheet of plywood. From a plank of hard wood 20 mm. thick cut out 67 and nail it onto the panel 68, which is 6 mm. thick, according to the arrangement 69; this will join the two arms of the lyre and the laths 14.



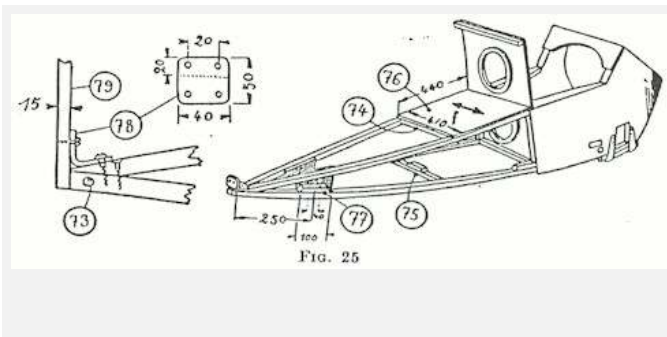
PLANKING

Turn the skeleton upside down. Cut out the tongue 70 according to Fig. 23 of 20 mm. and fit it to the edge 11. Copy this 14 times in plywood of 3 mm.

Seven thickness glued together one on top of the other along the edge 11 will make a longhorn curved in two directions to which you can nail, one after the other, the two bits of plywood of 3 mm. 71. Put one on top of the other, and glue, which will make the planking of the cock it.

The planking is supported at the rear with the batten 72 of 10 x 20 X 504, adjusted in front of the panel 47, with a file smooth off all the lower faces of the curved strips 70 so that a piece of 3-ply, 3 mm. curved in a triangular form, can be glued everywhere from the point right up to the batten 72. This will make a part of the fuselage bottom. Now cover the lyre right up to the panel

68-69 with plywood of 3 mm. I am sure that before going any further you will have already taken your seat in your cockpit. Is that not true?



REAR POINTS

Damp the longhorns with a piece of rag soaked in water over one meter's length, starting from the rear point, for ten minutes. Join them together in a point (Fig. 25) with a wood screw 73 of 4 x 40, with a countersunk head, taking care to interpose at 440 mm. from the back piece strips 74 and 75 of 20 x 20 x 410. Put into position the planking of the tool chest 76 in 3 mm., and also two stops of hard wood 77 fixed by two screws of 4 x 40 with round heads spaced at 40 mm., supported on the inside with plates of 3-ply of 3 mm. with the grain running vertical.

Cut out the two metal pieces 78 in mild steel of 1 mm. which will be bent. One will do to fix to the rear points, by means of screws with round heads

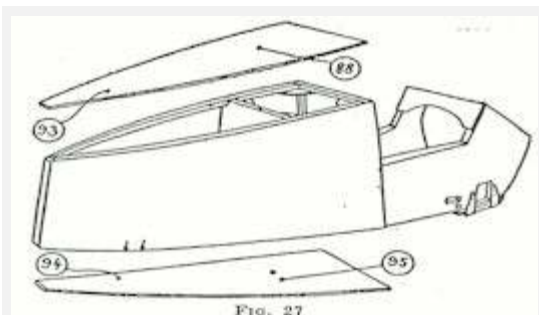
4 x 15, the sternest 79 made of hard wood 15 x 40 x 450.

Place on the back piece the laths 81 and 82 (Fig. 26), then the longhorns, 83, fixed in front on 81 by two gussets 84, and joined together in the rear by a screw, with the crossbar 86 of 410 mm. as for the lower point. The second piece of metal work 78 will Join them on to the sternest. During this work take care that the stern post is not out of line with the fuselage. Plane it and file it until it is exactly vertical with the fuselage.

The upper crossbar 85 is fixed on to the longhorns 83 by two gussets 86 at 350 mm. from the bar 81. In addition, this crossbar carries a piece of hard wood 87 screwed and glued. The whole is pierced with a hole of 7 mm. Carry on in a like manner with the crosspiece 75, which carries the piece 89 pierced with two holes of 6 mm. spaced 40 mm. apart. Place in position the bulkhead 90 furnished with laths 91, gluing it behind 74, 75, 85.

Bevel off with a file the plywood on the sides following the shading of 92 so that you can apply over it, without getting the extra thickness, the plywood sides of the rear of the body, which will be at this spot similarly beveled. With the help of several nails apply a piece of 3-ply on each side. Mark it off, cut it and nail it after having glued it everywhere. When you are gluing on the second panel, see that the sternest is still kept quiet straight. After it is dry, finish off all the rough edges nicely with a plane or file. You have then got Fig. 27. You can close up the box by the lid 93, which is pierced with a hole 88 of 7 mm. Take the screws out of the rear blocks 77 and mark their places exactly on the sides. Put into place, now, the bottom 94 of the box, pierced with the holes 95, right up to the seat. The piece of plywood of 3 mm. which will form the bottom between the crossbars 40 and 49 can be made all ready, and will be placed in position later.

The fuselage is now finished. You will have built it in four days. It weighs 16 kilos. If I had thinned down the rear and the bottom of 3-ply, and allowed certain laths to be made of smaller dimensions, I might perhaps have lightened the fuselage by 1 kilo. It would have been necessary to have reinforced it in other places and in spite of that the plywood would presently have got wavy. Some clumsiness, a stone, a branch of a tree, or piece of wire on the ground, would have made a hole in it. Our apparatus is not designed to be exposed in a gallstones, but is for service.



THE LANDING GEAR

The Rear Portion. The rear end of the longhorns 83 is joined by a metal strap 96 of 2 mm. material by three screwed rods 97 of 5 mm. metal. The pivot post of the rudder 98 in mild steel tubing is of 21 x 24. (This means that the thickness of the tube is 1.5 mm.) It turns freely with a play of 1 mm. in the metal strap 96 which is closed by a little tube 99 of 24 mm. material, fastened by a bolt 100 of 5 x 40.

This tube 99 is obtained by rolling in the vice a piece of material of 2 mm. around a rod of 6 mm. The other end of the rudder post 98 is inserted into a T 101 which carries the small axle 102 for the wheels 103 (Fig. 29). This T 101 turns, with a play of 1 mm., in an eye made from a piece of mild steel wire 104 of 10 mm. section, heated to red heat and bent into an eye 105, or welded with the bar 106. The arms of this triangle are bent inwards, and the two ends, carefully aligned to one another, make the axle which works in the metal straps 107 of 2 mm. These latter straps are offered up to the holes of the bolts 107 in 5 x 60, and marked off, taking great care that the rudder post 98 is carefully aligned on the stern post 79. It is separated from the latter at the lower end by 40 to 50 mm. and at the upper end by 10 to 15 mm.

An opening 108 out in the sides gives access to the nuts of the bolts 107 which fix a plate of steel of 2 mm. onto the piece of hard wood 77. Little pieces of aluminum sheeting 109 in .6 mm. thickness, and some wood screws, close these openings. The T 101 holds the eye 105 or 106 between metal and rubber washers, which are held from moving by the two bolts 110, which join the T to the rudder post 98.

The rudder post 98 is fastened to the rudder by the aid of four strips of metal 111 and 112 in 2 mm. section, which are bolted to it (5 x 40 and 5 X 60). At the spot where the bolts will pierce the rudder post, one will have strengthened it with a filling of hard wood 113, greased with wax or paraffin. The washers of metal and of rubber absorb the shock of the straps 111 on the collar 96.

The metal strips 112 are also fixed on to a tube 114 of 24 mm. length by the bolt 115 in 6 x 40. A rudder shock absorber of 12 mm. section 500 mm. long, joins the rudder post to the base of the sternest, passes under the metal fitting 116, and is fixed by the metal plate 117 and two big wood screws in 5 x 50. The two ends of this shock absorber are pushed inside the fuselage through a hole of 30 mm. cut in the bottom at a distance of 100 mm. from the sternest.

It is lightly stretched in such a manner that the weight of 30 kilos. placed on the fuselage begins to make the metal straps 111 move.

Wheels. The rudder post 98 of 24 mm. diameter, is pushed into the T 101 of 24 x 27 section. Make this possible, and a good fit, by smoothing up with a smooth file and emery cloth the end of the tube 98; the fit should be a close one. The two bolts 110 will keep the one from turning in the other. The tube 118 in 21 x 24 material is welded square on the tube 101. Take care that this welding has plenty of metal in it. It must be absolutely solid. As far as possible, in the course of this study, I have been at pains to avoid all possible welding. However, I recommend these given here on the condition that they are carried out by a proper tradesman. There are people who can weld in every town; it is quite an easy job. Take to the welder all your pieces well-prepared.

Two rivets 119 of 4 mm. fix the axle 102 in the tube 101. These rivets will be flush with the tube 101. The wheels 103 are made out of two discs in 1.5 mm. material, which are embossed by a hammer, and joined along their circumferences by twelve rivets of 4 mm. taking care that they are properly centered on a tube of 21 x 24. Any metal worker can help this work very considerably, because if you do it at home it will make a most alarming noise. However, you can do it yourself quite easily by hammering a sheet 200 x 200 on a piece of wood which has been hollowed out in the form shown, using a round faced hammer. After you have hammered out the material, you can then describe a circle, and cut it with your shears. The tube 122, with its ends slightly flared by hammering with little blows on the top of an anvil, goes through the middle of the wheel, and then one flares the other end in the same way. It would be a very: good thing to weld all this together.

A spring of eight turns in steel wire of 3 mm. is threaded on to the tube 118 and capped by a washer next to the wheel. A sleeve 123 is fixed level with the end of the axle 102 by a bolt 124 in 6 mm. This bolt goes through the little tube 125 which is 6 mm. high and 10 mm. in diameter, under the washer 126. This tube 125 serves as an axis for the metal strap 127, to which one will attach the turnbuckle 128 of the rudder cable. Without springs the wheels would make a noise like old iron of the most vexatious kind.

All this mechanism may seem to you most complicated. It is clearly much more so than a simple wood skid fixed by two bolts, but how often would you break that? With wheels like these you will not worry about cross wind take off, and will take off correctly every time. You can avoid obstacles on the ground, and you can steer yourselves amongst the spectators who seem firmly rooted to it. That is the fruit of my experience, believe me. Sacrifice two days to realize this arrangement, which altogether weighs 2.5 kilos.

The hand grip in steel rod of 6 mm. bolted to the left-hand side of the sternest will enable you to lift the tail about Without sticking your finger into the covering of the rear wing or rudder.

MILD STEEL SHEET

To Cut It. To cut a metal fitting out of a mild steel sheet of 2 mm. thickness might frighten some amateurs. The sheet is stiff and one does not know how to start about it. Look at the picture first of all, and out a pattern in cardboard with the holes cut in it. Place this pattern on your steel sheet and mark it with a thick pencil or chalk. Fix the steel in a vice with good straight jaws of at least 100 mm. length, and chisel it off with little blows with the edge of a cold chisel, sharpened as shown in 129 of Fig. 30. In this way the cut is good and smooth. Hold your chisel almost horizontally.

If you are obliged to hold the piece which has to be cut beyond the jaws, give your chisel a little slant, in order not to tear the metal more than you can help (130), which fatigues the metal.

Bending. One ought never to bend a piece of steel. at A right angle, even for the smallest little fitting. Calamity is hidden in those sort of bends, owing to the amount of hammering you give them, which this the metal before it is shaped properly. Always interpose between the piece you have got to bend and the jaws of the vice a piece 131 of the same thickness which has already been bent correctly. The piece 132 is dangerous; 133 is excellent. In order to bend a U as at 134, interpose some body 135. For example, an old smooth file.

Boring Holes. Pierce your holes far from the edges. When my drawings do not show the exact dimensions (I am not designing for imbeciles) always leave, between the hole and the edge of the material, a distance of 8 to 10 mm. all round the hole; 133 is very bad, 137 is good.

Fixing. On an aeroplane all bolts ought to be made so that they cannot come loose. When it is a case of a piece which will often have to be taken down, one fixes the nut 138 with a split pin 139 or a safety pin 140. In very careful assemblages, one uses castigated nuts 141 or lock nuts 142.



Fig. 30

When one does not foresee the necessity of frequently taking the pieces apart, it is quite easy to simply burr the end of the bolt with several blows of the hammer on the edges 143 of the bolt which pass beyond the nut by 2 mm. Before taking it apart, a few strokes with a file will replace the thread and remove the stop.

Not a screw, not an axle, not a wire bracing ought to be forgotten. If you neglect to fix, voluntarily, a dozen screws it may be that none will come loose; but if you forget one only, and one which may be important, you can be quite certain that that one will come away. In that case you will not be far away from scattering yourself over the country side in bits and pieces! That is the revenge of nature, which has a horror of emptiness and slackness. For the same reason the nut which you drop disappears from your sight... Where is it? Of course, there it is, hidden beyond the foot of the table.

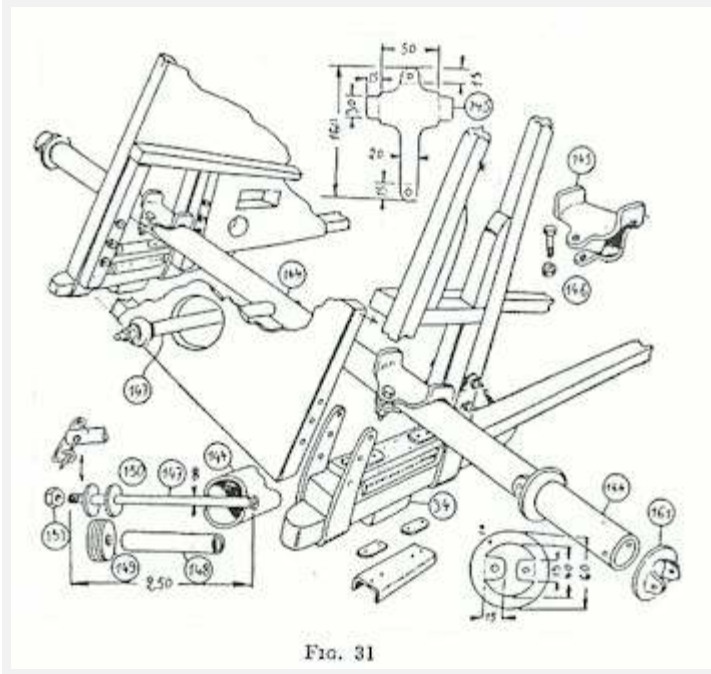
A piece of bread and butter always falls butter side down!

Obsession. As you construct, or file, or screw, always think that on some day close at hand the piece which you are occupied with will hold you suspended in space, several thousand meters above the ground.

B. MAIN LANDING GEAR

The axle is a tube 144 (Fig. 31) of 1.2 meters long in 36 x 40 reinforced internally with another tube 800 mm. long in 31 x 35. This makes a thickness of 4 mm. and weighs 4 kilos. 300. It is heavy very heavy. But it is solid. This axle will not bend. You will not be afraid of damage when you are running over bumps. Do not repeat the errors of the, author! A single tube would not be sufficiently strong.

The play of 1 mm. between the two tubes allows one to be pushed inside the other. If they were both the same size, you would not be able to get the inner one in place. I do not consider a filling of hard wood correct, because although it is lighter, it only stops bending, but will not prevent breaking. Its elasticity



allows the metal to crystallize, and one day your axle will break under a light shook.

A collar 145 is fixed on to the tube by the bolt 146 of 6 mm. It will prevent the tube from sliding in the rubber shock absorber, in the same way that the block No. 34 holds the latter under the skid of the body. Do not drill any hole in the axle at this spot.

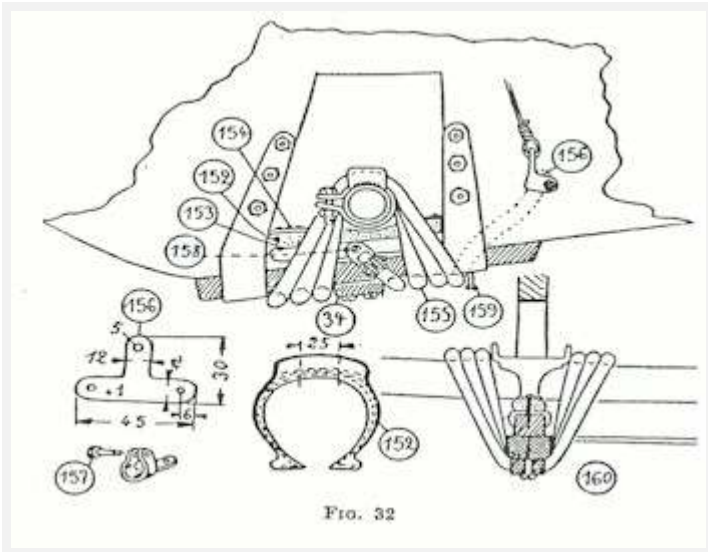
A piece of rod 147 of 8 mm. goes through the axle at its middle point, then the tube 148 made out of sheet metal of 1 mm. rolled round, then the washers of rubber 149 between the two washers of metal 150, the whole held by the nut 151. This prevents the axle from turning by supporting it on the front planking through the hole 50.

The axle bears down on the pad of rubber 152 of a thickness of 12 mm. out from the tread of an old motor car tire. This pad is fixed on the washer I53 of aluminum of .6 mm. and held by two screws and a plate 154.

ELASTIC SUSPENSION

The rubber shock absorber 155 of 12 mm. which commences to stretch under a pull of 17 kilos., and which has a length of 1 meter 90, is fixed at each end into a metal fastening 156 in metal of 1 mm. with a bolt 157 of 4 mm. One end of the shock absorber is fixed under the axle by a screw 158 in 4 x 20. The shock absorber passes behind the stop 34, and afterwards six times round the axle, and under the skid as shown in the drawing. One pulls on it until it is just a little stretched. No slackness. The other end receives a wire of 2 mm. which will be taken and attached to a screw placed conveniently under the seat planking. The screw 159 prevents the last turn from slipping.

Before cutting the shock absorber one binds it with rubber tape (two turns), and one cuts in the middle of the binding with a knife which has been well sharpened.



In its longitudinal sense the suspension has the appearance 160, where one sees the axle, its collar, its pad of rubber, the strip of aluminum, the longhorn of the fuselage, the skid which reinforces it, and the lower stop with, on either side, the three turns of the shock absorber, which makes altogether, on each side of the body, twelve turns of shock absorber. The machine could roll on one wheel without stretching the shock absorber, except over bumps.

The wheels are fixed on the ends of the axle by washers and collars 161 (a bolt of 5 mm. horizontal) cut out according to 162 in metal of 2 mm. Bits of tube 40 x 44, of a length of 15 mm., will also be quite suitable. Interpose a washer between the wheel and the sleeve.

Work one day. Weight with wheels, 12 kilos.

WHEELS

I recommend very strongly the dimension of tires 450 X 100, which, when lightly inflated, absorb most of the roughness of the ground. Only the bigger shocks will have to be taken by the shock absorber. One blows up these pneumatic tires so that they hardly preserve their roundness. Frequently grease the axle. These wheels are small. The body of the fuselage is at a distance of 14 cm. from the ground. That may seem to you rather small. In practice I have never had any trouble with it. That should not prevent you from making a careful inspection of the ground from which you are taking off, and from flattening with blows of a spade any bumps which seem a bit too high.

A suggestion for manufacturers. They should study specially for aeroplanes which weigh in flight 200 kilos., wheels which weigh 1 kilo. for tires and 1 kilo. for hubs. That ought to be possible. They would sell like hot cakes! We would also like to have a tail wheel of spherical shape, with a diameter of 140 mm.

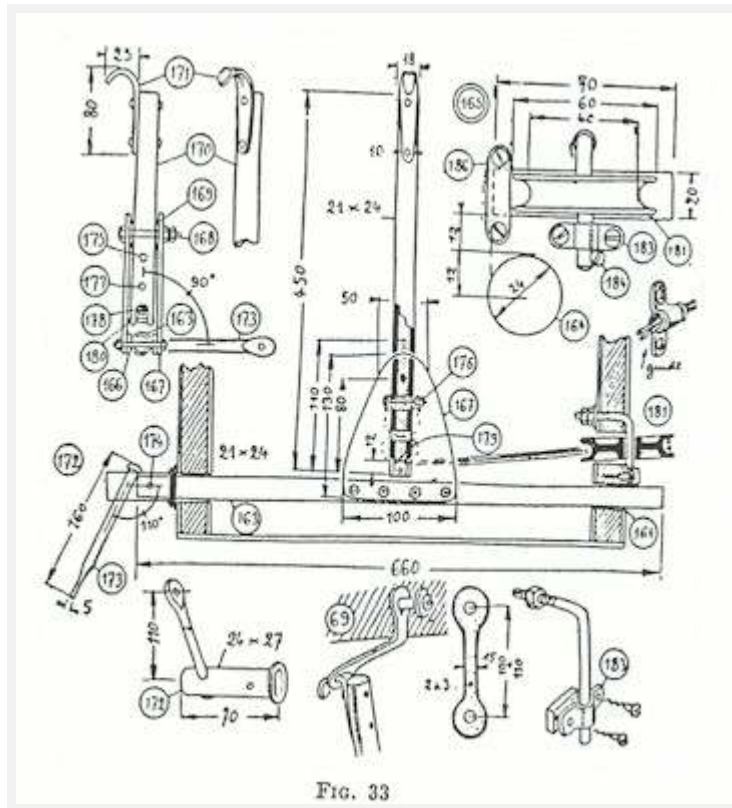
THE CONTROL STICK

A tube 163 (Fig. 33) traverses the fuselage from side to side underneath the rectangular hole 26. You will have, after buying this tube, drilled with a bit and brace a hole 164, and fitted this with the aid of the rasp to the diameter of this tube, about 24 mm. Paste the interior of the tube with a brush charged with melted paraffin wax, very hot. In this way the hole will remain lubricated for ever. The play admissible will be 1 mm. If too much, adjust it with a little washer of metal, through, which the tube can pass. The center of the tube 163 is held between two blocks 166, and two cheek pieces 167, by four bolts of 5 mm. Between these strips, on the bolt 168 of 6 mm. and the washers 169 of 1 mm., the control stick 170 pivots. On the top of this stick is riveted a hook 171 in steel of 2 mm. which will prevent your band from slipping off, and also will enable you to join the stick to the dashboard 69 (Fig. 22) by rubber strips cut from, an old pneumatic tire. These strips will relieve the pilot of the continuous pull of the stick in a forward direction.

The tube 163 extends beyond the sides of the fuselage for about 50 mm. Two flared sleeves 172 prevent it from sliding laterally, and if possible without any play. Put washers between the fuselage and the sleeves. These sleeves also carry the levers 173 in 10 mm. bar heated to a red heat, flattened at one end and riveted at the other so that they will not come out of the sleeve. This sleeve is fixed to the tube 163 by a bolt 174 of 6 mm., taking care that the lever, when looking at it from the end of the tube 163, is at right angles to the joystick. This latter disposition is for the command of the wing, to which the eyes of the levers, one on each side, will be fixed by a control cable. The control of the rudder and wheels can be placed in position. Two cables of 5 meters long of 2.4 mm. section steel and extra flexible, will be passed through the hole 175 of 6 mm. in the joystick, and prevented from moving at the middle point by the bolt 176 of 5 mm. Each double turn will cross with the other in the hole 177 of 5 mm; then, in a similar manner, in the fork 178. Before this, the joystick will have been filled with hard wood, well greased with paraffin wax, level with the base of the stick. The fork, partly of wood and partly of metal, will be filed round according to 170. The rivet 180 of 4 mm. prevents the cables from escaping from the fork. It is flush with the outside of the joystick. A drop of oil will prevent wear on the cables.

Each double cable, of a length of 2 meter, 50, passes over the pulley 181. (This is a cast pulley and has a very wide groove: it can be got at any ironmongers diameter at the bottom of the groove 40 mm. at least), which revolves on the axis 182 of a diameter appropriate to the hole through the center of the pulley. A nut on the interior of the fuselage at one end, and a bearing 183 at the other, and a screw 184 of 5 X 25 fix this axis, which will be slightly inclined by means of a block under the bearing in order that it can be aligned with the bottom of the control stick.

Finally, the double leads go and join up with the turn buckle 128 (Fig. 28) where they are attached by the grip 185, adapted for cable of 4.5 mm. Bind each free end, and join the ends to the cable. They will be about 50-100 mm. beyond the grip.



The little piece of strip steel 186 of 2 mm. fixed by two screws close up to the pulley will prevent the cables from jumping out of the groove and jamming if they become slack. This is a rise precaution; one never knows. Jamming of the cable is much to be feared, and if there are only in the Flea two pulleys, it is two pulleys too much!!!

Time, one day. Weight 1 kilo. 600.

WING SUPPORT

The support is a pylon made of tubes, which sustains the wing and positions it in relation to the fuselage, after it has been fitted with its bracing wires. It is made (see Fig. 34) of two tubes 187 in 17 x 20, Welded to two cheek pieces 188 of 2 mm. separated by a block of hard wood 189 and joined by two bolts of 6 mm. Where welding is not possible it can be bolted together as in 190. This is the head of the pylon.



FIG. 34

The feet of the pylon, lightly bent (at red heat), are stuffed with hard wood, and are pivoted at the U piece 191 in 2 mm. material, furnished with a bolt of 6 mm. This is joined to another piece of metal. work 192 by two bolts of 6 mm. which go right through the crosspiece 67, to which they give great rigidity. On the other hand, the metal piece 192 is fixed by three bolts of 4 mm. to the three laths 14, 15 and 16 of the landing gear.

It would be better if the feet of the pylon were finished off by a transverse tube welded on to them 193. The head of the pylon is kept in position by a tube 194 about 300 mm. long the exact length will be decided at the moment when the wing is adjusted and which is pivoted at either end on the tubes 195 of 30 mm. made of strip of 1.5 mm. rolled. The axis tube of the foot is fixed between two strips of metal, which will be bolted to the motor when that is in place.

The tube 195 of the head of the pylon is the axis on which the wing will pivot. For that, a bolt made of screwed rod 197 of 10 mm. material 200 mm. long goes through the wing, and holds to it the metal piece 198 which is bent into a U and welded on to a tube made of rolled strip of 2 mm. thickness. The pivoting is assured by these two tubes revolving one on the other, one being fixed on to the pylon, and the other fixed to the wing. In case it is impossible to weld, one can arrange a metal fitting without a tube but doubled 199. The tube 195 will be so arranged that the metal piece 198 moves freely on it, but without lateral play. Perfect adjustment of these two tubes is useless; whether there is one or two mm. of play is of little importance, provided that they are approximately round. A drop of oil will take care of everything. Let the engineers laugh. Why should one give oneself trouble which leads to nothing! Time, 1 day, weight 1 kilo. 500.

CHAPTER X

WINGS! WINGS!

CHOICE OF SPAN

My ambition is in accordance with the principal problem which faces the amateur, a wing span adapted to the space for construction which everybody has. The ideal is a room or apartment of 3 meters by 4 meters. The machine itself is small. This room should suffice for it. The wing, alas, is the largest bit! A span of 4 meters . . . how splendid it would be! I have made it; the front wing exactly like the rear wing, which I give a little further on; inter changeable and minute.

Last winter I used to fly on 51 meters span. Could I try 4 meters as a test!!

The first profile, with a flat lower side and the tail turned up, showed itself perfectly stable. It did not lift well. The machine meandered across country, but it wanted the full power of the motor, and it scarcely climbed at all. I caught on to little bumps like an old man hoists himself up a staircase; by little jerks of ray joystick and blowing. . . .

There was not enough excess power. I dismounted my wings, and curved the ribs more. The same spars! the same span! The lift was better. Another journey in the air. It is much better. There is too much incidence on the front wing, not enough on the rear one. My surfaces are badly adjusted and do not lift as well as they ought to. The span of 4 meters would be usable if I could advance my front using by 15 cm. or put the pilot back by 20 to 25 cm. Impossible. The airscrew turns already at a distance of 4 cm. in front of the one; the rear wing is right up to the neck of the pilot.

There is only one solution, to augment the span of the front wing. How terrible! and now what has become of my room 3x4 meters? So much the worse! We must fly somehow or other. The amateur will get himself out of the difficulty as well as he can.

Here is the same profile, but a span of 6 meters. Take off in 50 meters. Splendid climb! let us test the level flight! I let my hand go forward. Hello! I find myself seizing the control stick with both hands. I pull on the controls as though to break everything. The profile is unstable. It is necessary to bend up. the tail ends of the ribs.

I take the wing down again. I double the turn up of the tails of the ribs.

Recover and revarnish. I take off. A little less lift, but the wing is stable. The pull on the hand is the same at 20 degrees of incidence as at 3 or 4 The balance in level flight is correct, stability perfect. At last I have arrived. There is no need any more to weigh everything before one takes off. No need to, economize on the movable load of petrol, luggage, parachute, etc. Come! The span of 4 meters is certainly an elegant technical problem which still interests me, but for the moment I think it, is much better to have 200 turns in hand on the airscrew. This is more prudent.

If one only wants to flutter, so to speak, to learn to fly on little journeys of two or three kilometers above a flat open plain, where one can land anywhere, then this span of 4 meters is possible. It is better than a machine which only rolls on the ground; better than a "penguin," because it really flies "in the air" and the principle incorporated in the Flea will excuse faults of pilotage which in an ordinary aeroplane would lead to catastrophe. Its lateral stability is immense.

If you are light (60 kilos.) and are only thinking of short journeys, then a span of 5 meters will suit you very well, but on 6 meters you can weigh 80 kilos., and you can carry with you enough petrol for 3 or 4 hours flight.

Whether on 4, or 5, or 6 meters span, the construction is identical. You only have to elongate at your discretion the ends of the wings (which means a few extra normal ribs to nail) and alter the attachment to the bracing wire. The central part remains unchanged. This last wing of 6 meters, longer and deeper and better arched, is definitely superior to that I had last winter. Here it is (July, 1934).

Figure 35 consists of two technical drawings of a ship's hull. The top drawing is a plan view (top-down) showing the hull's length of 6,000 units and a beam of 23 units. It includes various internal structural dimensions and station numbers (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100). The bottom drawing is a side view (starboard or port) showing the hull's length of 3,700 units and a draft of 7.50 units. It includes various internal structural dimensions and station numbers (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100).

The framework of the wing (Fig. 35). is made up of 18 ribs threaded on to the main spar 200 which. is 6 meters long. A small rear spar 201 of 5 meters 20 is inserted into the 14 tails of the ribs, which are all of the same pattern.

The two ribs on the extreme ends are of different pattern, because of the tapering of the wing in plan. The leading edge 202 and the trailing edge 203 (in treble strips glued together) with the small spar triangulate the framework, which does not need any other stiffener. And so, in the interiors of the wing, except for the nailing of the plywood, there is not a single piece of metal. No fittings, no wires, no turnbuckles. The wing is supported on the pylon by its center at a place where the block 204 is shown, while the system of bracing cables, joined to the wing at 205, keeps it steady but allows it to pivot about the axis 204, 205. The pivoting is controlled by the cable which joins the lever 173 of the control column to the small spar, to which this cable is fixed at the spots marked by the four blocks 206. A spring attached at 207 pulls down the wing in front.

MAIN SPAR

The spar is made of two flanges 207, 208, in 15x60 material planed up to points according to Drawing 209, curved and maintained in correct form by two webs 210 of plywood of 1.5 mm. of which the grain is vertical to the depth of the spar. The depth of the spar is 130 mm. It is perhaps difficult to find ordinary pine free from knots as long as 6 meters. This great length also is rather inconvenient for delivery. Let us start then, with lengths of 3 meters 20, which can be joined together in the middle with a solid gluing on the bevel.

Plane up at the same time (A) to a length of 400 mm. the ends of the two planks 15 x 60 which are put side by side flat and fixed together by a bolt. Take care that the surface (a,b,c,d) is quite flat and regular. After planing it pass a file or rasp over it in order to take off the polish.

Point the other ends as in 209. Join together (B) the bevels simply with gluing, and align carefully the two planks, which will be temporarily fixed by two little nails at e.f. Glue all over this, separated by double leaves of paper, and press it carefully (C) between two blocks (G and H) in two vices or two strong screw presses (I. J.). Leave it to dry, in the summer 12 hours and in the winter for 24 hours. Make ready for the two wings the blocks 204, 205, 212, 213, which can be of good pine or of beech. All the holes are of 11 mm. Get ready also five screwed rods of 10 mm. 180 mm. long.

ASSEMBLING THE SPAR

After having taken the two flanges out of their presses and smoothed their four faces correctly, drill a hole of 11 mm. in the middle, and two holes 500 mm. apart at 1 meter 300 on both sides of the center. Stated more exactly, these double holes will be in the upper flange, a little closer to the center by 3 mm.

Place the two planks on two trestles, and join them simply by gluing (D) with the block 212 fixed under the blocks 204 (also glued) by the screwed rod 218 of 10 mm. and two nuts with washers. Lock nuts of 10 mm. will be good enough, and are lighter than ordinary nuts. Make certain that these two planks are quite parallel from end to end.

Now glue (E) on each side two plates 210 of plywood of 1.5 mm. 130 mm. broad, with the grain running as in (F), and of a length of 0 meter 50 cm. (500 mm.).

With the aid of a cord 214 or a wire of 2 mm. and of the kingpost 215 made of a tube, or bamboo or strip of wood 1 meter 500 long, pull up the points of the flanges in such a way that the thread 216, stretched between the points, passes at a height of 230 mm. above the central boxed portion.

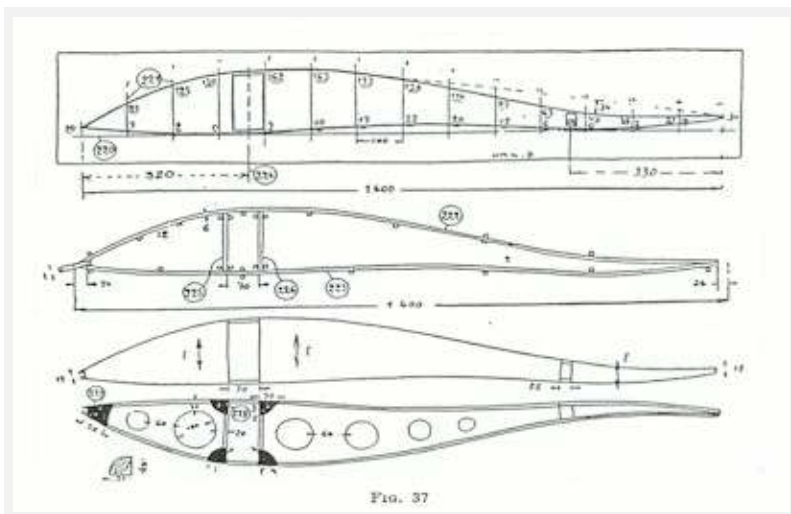
Introduce with the aid simply of gluing the blocks 213, and fix them under the blocks 205 (without gluing these latter) by screwed rods 218. A little temporary block 217, of a height of 40 mm. will separate the flanges at 300 mm. from the ends.

Take care to see that the arch of the flanges, as checked by the thread 219, is approximately equal to the right and to the left hand. Furnish, then both faces of the spar from end to end, with strips of plywood 1.5 mm. (nailing it with fine nails 8 mm. long in a zigzag at every 15 mm.). Put the plywood strips side by side without overlap.

Altogether this spar of 6 meters requires one square meter of plywood. It weighs 7 kilos. Construct in the same way the spar of the rear wing, but on a span of 4 meters, and with a curve under the thread 216 of 180 mm. This spar weighs 5 kilos.

Looking forward to the necessity of folding the wing for transportation along the road, place the blocks 213 at the same distance apart as on the front wing. Let everything dry for 12 hours before taking out the screw rods and the blocks 205.

You will be surprised at the stiffness of these beams. They give the impression and a perfectly correct impression of really solid bits of stuff, to which one could trust one's life. You can make these two spars in one day.



RIBS

Cover with white paper a board 300 x 1,500, and mark out on it the profile of the rib as follows:

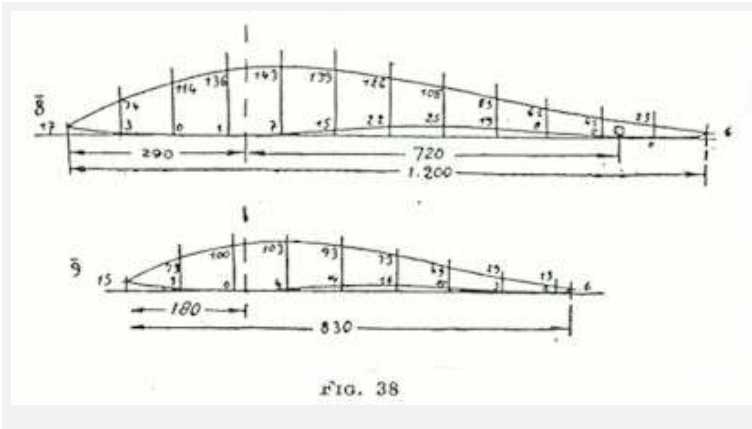
Draw a straight line 220 (Fig. 37) at 50 mm. from the lower edge. On this line draw 15 perpendiculars 221 spaced 100 mm. apart and mark them in accordance with the drawing given. For example, 20 marks the point of the leading edge, 7 and 81 are the respective distances to the line 220 of the lower side and the upper side of the wing, and so on right up to the tail of the rib, of which the trailing edge is 30 mm. above the line. This line 220 is the chord of the wing.

Join all the points together, and there you see the form of the profile of the wing.

Two laths 222 and 223 in 6 x 12 material are held between nails of 2 mm. of which you will have out off the heads, and which mark out the lines required. At 320 mm. from the leading edge mark off the line 224. This is the axis of the bolts of the spar. Place the laths 225 and 226 in 6 x 12 on either side of this line, leaving a free space of 70 mm. This is where you will thread the spar on the ribs. Join the two flanges 222, 223 by a web of plywood 1.6 mm. thickness. Keep the grain in the sense shown by the arrows. Nail it every 25 mm. with nails of 8 mm. length.

Dismount it. The rib is now retained in form. Nail now the leading edge gusset 227 and the four gussets 228. In this way construct 23 ribs. The 23rd, carefully finished, stained and varnished, will be suspended somewhere in your office where you can see it, and where it will recall for you later on these hours of happy work.

With a cutting compass lighten the ribs. This is not any trouble. You will get off about 20 grammes from each web; it is very little, but together it will



lighten the set of ribs by half a kilo, and that is certainly proper aviation practice. The rib weighs 160 grammes. It requires ten minutes to nail it up. The ribs which are not of the main series the ribs 8 and 9 each one repeated four times over, will be designed and constructed in the same manner in accordance with the drawing of Fig. 38.

One can prepare the webs and laths in five hours. All 31 ribs can be nailed up in one afternoon. If you allow several hours for rubbing up with sandpaper, call it 1 1/2 days more or less. The batch of 18 ribs weighs 3 kilos. One square meter of plywood of 1.5 mm. makes webs for eight ribs.

NAILING

You will find it very easy to nail two nails in three seconds, if you utilize a box of nails put on a slant. This slope will have the effect of making the nails roll until their heads are all pointing downhill. With a pair of pincers you can then pick up easily each nail, and bring it under the hammer with the point about 1 mm. from the wood; at your first blow the nail is stuck into the wood. Take away your pincers, and with one more blow the nail is driven home.

You get along quite fast, and will avoid damaging your thumb and fingers. Take the pot of glue well away from the box of nails. Sometimes it happens that in the heat of the work you will stick your

spatula for gluing into the box of nails, and you will bring up a magnificent tuft of them, unless on the other hand you absentmindedly stick your fingers into the cold gluey mass!

THE PROFILE OF THE FLEA

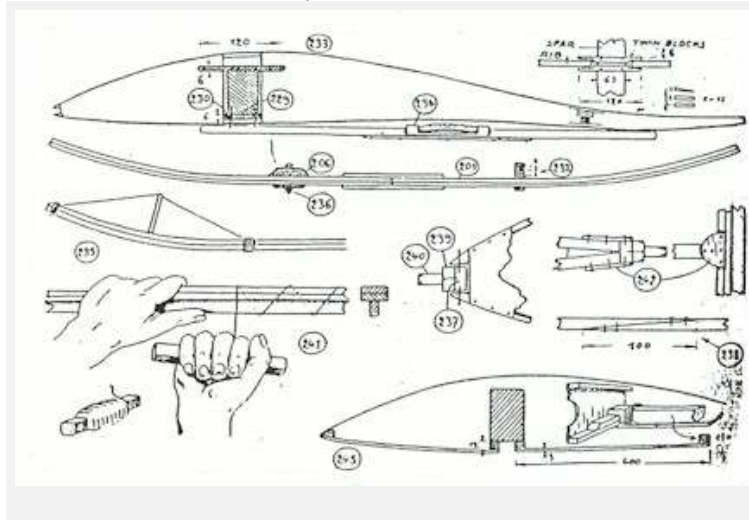
Do not show this profile of the wing, with its pointed leading edge to any good aeronautical engineer. "What an old jackass," he will say chaffingly. For this engineer knows any amount of things, but he does not know how should he know it since it is not in his books? that one can fly without danger with small power and that, under these conditions, the cruising flight of the Flea only uses a small set of angles of incidence.

This pointed leading edge has been designed for those conditions in which it is actually better than any other profile for proof of this look at the wings of the super racing machines of the Schneider Trophy but it would present an inferior efficiency, for example, if one climbed at a high angle of incidence, if the motor allowed us to do so. But since this is impossible for us, because of our rabbit power, I am pleased. For simplification, lightness and speed of work this pointed leading edge is unrivalled. It is also which is very much more important more solid.

Well! Monsieur Engineer, would you like a rounded leading edge and some ailerons? Why, in that way you would give yourself two months of most wearisome work, and quite uselessly. You would hardly get any additional speed or any other advantage. Some of the constructors of H.M.8. have wished to try out the rounded leading edge. Unfortunate people!! They have sworn to me that they would never again try the same thing. The two wings of the Flea will be ready in one week.

ASSEMBLY OF THE WINGS

Place your spar on two trestles, with its points turned towards the ground. Thread the ribs on it in order, with their lower sides uppermost. A block 229 in material 6 x 12 X 70 is placed under each rib, is nailed and glued on to the spar by two fine, long nails 230 (Fig. 39). let them dry for two hours. The two middle ribs are separated by 400 mm. and the remaining ones are 315 mm. apart. Turn the skeleton upside down, place in position the twin joining blocks 233 made of 6 x 12 x 120. Nail on to the main spar, and simply glue on to the web of the ribs in such a manner that all the lower surfaces of the ribs are parallel, which can be verified with a spirit level 234.



The small rear spar 201 is in two pieces right and left, each one threaded through its seven ribs all of a kind, and through the one of different pattern. Each half spar is made out of two strips of 10 x 20 mm. (or one strip of 20 x 20 split), 2 meters 700 long, whose elasticity allows it to join the turn up of the ribs, following the curve of the main spar. These two half spars are joined between the two middle ribs by two strips 10 X 20 of a length of 400 mm.

One glues them together before threading them into place, and one makes certain that the glue holds properly by nailing or binding them. If you are afraid of deformation to the trailing edge of the wing, before you bind up the little spar, by means of a cord and a kingpost bend up its points as you did in the case of the large spar.

The little spar of the rear wing is made out of one single piece of 3 meters 200 long, carried out in the same manner.

The bottom strip of each rib is directly nailed with a single nail to the small spar. After this, one blocks the upper surface of each rib with little bits of lath 6 x 12 as at 232. Keep the ribs at the same distance apart as they are on the main spar, to which they will be approximately at right angles. Between the ribs 2 and 3, and 4 and 5, fix the blocks 206 with washers and bolts 236 of 5 mm. At these points the cables will be fixed which govern the incidence of the wing.

THE EDGE

First of all for the leading edge. A lath 237 made of 6 x 12 material is fixed flat at the bottom of the nose of the ribs. Use two nails. This lath goes from end to end of the spar. If it is necessary to make it of more than one piece, then join together by bevel as shown at 238. Another lath 239, also placed flat is fixed to the first one, and then the third one 240, which is stood on edge. This latter one is simply glued and is bound strongly into place with a thread which makes one turn about every 30 mm. (241).

In the same manner carry on for the trailing edge; in this case the first lath is fixed to the tail end of the ribs by two semi-circular gussets 242. If you are afraid of breaking the laths when you begin thump moisten them with a rag soaked in water five minutes before you start to work.

Two gussets 243 join the two edges the leading edge and the trailing edge in the point at the end of the main spar. Two other gussets 244 join the trailing edge to the small spar (see the plan of the wing). After it is dry one night trim up the edges with a file. Glue the blocks 204, 205 above and below, fixedly by bolts with washers. The fuel tanks are placed in the front wing between the central ribs one tank in front of the main spar, of 12 liters capacity, the other behind it of 15 to 20 liters which gives altogether a total of about four hours of flight and a range of action of 400 kilometers. These tanks are placed on planks 245 in 3 mm. plywood, glued and screwed under the central ribs, the main spar, and the leading edge. They are afterwards wedged in their compartment and finally keep in place by the covering. Without the tanks each wing skeleton weighs 14 and 9 kilos, front wing and rear, and requires five hours work to assemble.

Photograph the skeleton of the wing. It is the last time for a long time that you will see it in the open. It will be a good souvenir for you and you can also, as a mark of friendship, send a copy of it to the author of these lines, who will be delighted to receive it.

COVERING

The material for covering the wing is generally sold in widths of 1 meter. For the front wing six of these widths, 3 meters 10 cm. long will be joined on a sewing machine along their edges. Cover the

skeleton of the wing with this piece of material, of which the free edges will be at the trailing edge of the wing.

Stretch it first along the whole of the bottom of the wing, nailing the turned-up edge at the trailing edge:

1. Tack it between ribs No. 1.
2. Tack it then at rib 6, pulling it tight between 1 and 6.
3. Tack it on the back (tack every 40 mm.) between 1 and 6 quite making certain that it is straight as regards the run of the thread.
4. Tack it to the two ends of the wing, pulling it very hard, and tacking with four tacks.
5. Now tack between the ends of the wing and rib No. 6, pulling it tight in the direction of the span.
6. Now stretch the bottom face by pulling the cloth from the direction of the leading edge, and put in one tack at the nose of each rib.
7. Turn the wing over and tack it on its back pulling with all your strength, and following the same order as you used on the bottom face. Use pincers in order not to break your fingernails. Note that the free edge is eventually tacked (after turning over) along the lower surface of the trailing edge.

Now finish with the rounded parts of the leading edge.

Tacking is best carried out when holding the wing vertical, standing on its leading edge. An assistant holds it upright, and at the same time can hand you the box of tacks. Stand on a small stool of 200 mm. height, and get right opposite your work.

Do your work during a period of time which is warm and dry, or else in a room which is warm and dry. Cut off the excess of the cloth, leaving after the final tacking a free margin of about 40 mm.

The skeleton is now enclosed in a sack like an ordinary mattress. Like a mattress, sew it through from side to side along each rib, with the aid of good hemp string and a mattress needle 22 cm. long. Knot your string every 80 mm. without cutting the thread between the knots, which will be on the top of the wing. Pull your string quite tight. This sewing, due to the dihedral of the wing, helps to stretch the cloth covering very, firmly. Time for the covering 4 hours; for the sewing 2 hours.

All round the rounded ends and along the trailing edge, the spare strip of 40 mm. referred to above will be glued with cellulose varnish, moistening the cloth well with this both above and below, and leaving it to dry completely (5 or 6 hours).

DOPING

Choose a warm, dry, sunny day. Operate outside in the shade in the afternoon. Your can of 20 liters of cellulose dope is placed on a chair. Fill a bowl with this varnish, and taking up a good brushful with your "codstail" brush 60 mm. long, apply a layer, rubbing it well into the cloth, which becomes semi-transparent. Spread well any excess dope all round with strokes of the brush. Do not economize in your dope. It is not there to make the wing look pretty, but to stiffen the covering.

Carry on progressively from front to rear, rib by rib. On going on to the next strip run over the blobs which will form on the earlier one., but do not take too much trouble about it. If the weather is damp the varnish becomes milky as a result of condensation. Do not carry out the work at such a time. If it is warm, two hours after the last stroke of your brush you can start on the second layer. Two layers are enough. An extra layer on the back is still better. Four layers are very good.

The cuttings and gluings and sewings ought to be covered with a band of notched fabric. One applies the dope bit by bit to the surface and then to the band, which is rubbed down with a brush

soaked in dope. When it is dry, watch it to see that the notches do not try to spring up. Press them down with the fingers.

Before it gets dry wash the brush in water and soap. The dope will come off in little white pellicles.

The two wings are entirely constructed, assembled, covered and varnished in eight days. They weigh each as follows:

The wing with the tanks for petrol and oil about 20 kilos and the tail wing 12 kilos.

RUDDER

The construction of the rudder follows the principle of the single spar. A lath 252 in 20 x 20 material carries a reinforcement 253 of hard wood, and is thinned down at 254 to 20 x 12 section. With the lath 255 in 20 x 12 section it forms the flanges of the spar. Nail on the top of it every 200 mm. strips 6 X 12 forming ribs cut off to the lengths indicated. The upper ribs 256 go beyond the spar in order to make the leading edge and compensating surface. The lower ones 257 do not go in front of the spar. Fill up the space between the ribs with strips 258 in 6 x 12 running along each flange on both sides, and cover with a strip 269, of 3 mm. plywood, 100 mm. wide and 1 meter 300 long, with the grain in the direction of the length. This plywood strip goes beyond the sharpened ends of the flanges of 12 mm. In the empty space so formed, place two strips chosen from material with good straight grain, curved after being damped for 10 minutes, then bound and glued after having been nailed on to the ribs as at 260. As in the case of the trailing edge of the wings, gussets 261 help to fix the edge to the tails of the ribs.

A web 262 of plywood of 1.5 mm. makes the rib rigid. One covers the rudder with fabric just like the wings, and puts on four layers of dope.

Time: for making the skeleton, four hours; for covering, one hour weight 2 kilos.

Now has come the moment to paint a beautiful emblem on the rudder. The emblem is the signature of the amateur. It is evidence of his workman like taste and handywork. To put a successful emblem on a rudder is like rouge on the lips of a pretty lady; it finishes the toilet. The airframe is now finished. It remains to adapt to it the motor airscrew group, without which it is a face without an eye, a body without a soul, and is not any good to anybody.

CHAPTER XI

THE ENGINE

With out an engine no flying is possible. That is a basic principle which no man with a conscience can deny, even in so far as it concerns the sport of the amateurs A bad engine . . . bad flying. A good engine . . . good flying. The basis of my aviation campaign for the light aeroplane H.M.8 was the employment of a motorcycle engine. I have grown older. All, campaign has also grown. My experience has been confirmed; and we know where we are going. The motorcycle engine, even if not specially made for aviation remains still more than ever our motor, for if we have developed during four years, it also has been perfected favorably for us. That has not prevented me from putting pressure on several constructors in order to try and persuade them to offer us an engine specially designed for our purposes.. I assure you I have not economized my breath or my bus and train ticket! I have certainly worked hard! "Monsieur, the Director, can you not adapt for us on to a single crank-shaft two of your single cylinder engines which on the motorcycles X do so well and with which I have experimented on my little aeroplane! If you would, the amateurs of aviation would have the engine of their dreams! Look, here is an article which I wrote on this subject in Los Ailes of the 2nd April, 1931. It will show you what we want."

"Amateurs? Pah! that's not a public! Do you think I would sell ten engines? Light aeroplanes? Do you really believe in them? It is easily seen that you are not of the aviation world! That you are asking of me would cost me 12,000 francs in experiments. Give me half of this and I will try."

"I am sorry, Monsieur, the Director. If there had not been any motorcycles, if there won't soon be any air sportsmen, your industry would not exist. It is for you to see a possible public, to prepare your market in advance by gathering all independent opinions and not only those of bad counselors, and to know how to sow your seed to best advantage in order to reap the fruits. He who risks nothing gains nothing. As for me, amateur aviation (that is something that is really outside real aviation), is not a question of money."

I talked on these lines in three factories. In another my explanations were continually interrupted by the telephone. In yet another they were hardly polite to me. There is in the book by Alphonse Daudet called Tales of my Windmill, the story of the Pope's which kept a kick for several years. I experience at the moment a wicked pleasure!

I PREFER THE TWO-STROKE ENGINE

From in point of view safety is everything. My very mediocre qualities as a sportsman some day; perhaps, will do me a bad turn that depends on me. I would not be either more or less in danger on a boat or on a motorcycle. But I won't admit that the risk comes from an engine in which I have confidence.

Strength. The two-stroke engine has nothing to break nor to come to a stop.

Sweetness. Since they have, an explosion every revolution each cylinder is the equivalent of two cylinders of a four-stroke. With perfect safety, speaking mechanically, it can turn twice as quickly as a four-stroke. It is, therefore, the equivalent of four cylinders of a four-stroke. And as I have two cylinders, as far as the airscrew is concerned it is just as good as an eight cylinder four-stroke engine!

That explains the astounding strident note, like a mechanical saw which one can hear before one can see my Flea.

And it is this division of power into eight times smaller units that makes it so much less brutal and so much easier on chains and gears and shock absorbers and mountings, etc.

In the case of a reduction gear which has been manufactured by the amateur in little bits bad workmanship is therefore of less consequence and the machine is less likely to Puffer from vibrations.

Flexibility. The power curve of a fourstroke engine is very pointed. That is to say, it gives its maximum power at a certain speed and outside of this its power falls off very quickly.

On the other hand the two-stroke is much more supple; its power curve is flat. The engine which I use gives 18/20 h.p. at 3,500 to 4,400 revs., therefore its adaptation to an unknown airscrew is very easy. If the pitch is too great the airscrew will slow the revs. down, and if it is too light pitched the revs. will increase: in both cases we get almost the same amount of power. The engine does its work and the aeroplane flies. The opening of the throttle always regulates the consumption, and the consumption always gives a proportional amount of power.

One could with a two-stroke almost use an airscrew without a rev. counter, adjusting it by eye! I tell you this is the amateur's motor.

Fire Risk. On account of its constructional principle the two-stroke engine can never set the carburetor alight; any back fires are extinguished in the crank. case pump before they can get out. when the two-stroke suffers from too weak a mixture there comes from the carburetor not a flame, but smoke.

A flame arrestor is of no use on the Flea. On the one hand the engine is not cowled and therefore is very much in the open air; on the other the tank is away in the wing separated from the engine by a violent current of air. Even if the carburetor could be set on fire (as in a four-stroke engine) the flame would be blown out before it reached the tank. This, for those who are afraid of fire, is of vast importance.

You know what you ought to do in case your carburetor catches alight? Close the petrol tap and open the throttle wide.

BREAKAGES

The two-stroke engine is simply full of good qualities. Let us be fair to it. Why is it not more largely employed?

1. Aviation for the common man which would show its value hardly exists.
2. It is not very good for surface locomotion because its slow running is bad, and because even if it performs so marvelously in small sizes, in larger sizes it uses too much fuel and too much oil.

CONSUMPTION

Too much fuel? Yes! Quite 25% too much, because the four-stroke will use 300 grammes, while the two-stroke will use 400 per horse-power hour. (I am talking of real consumption, actual experience, and not the figures given in certain text books.) Certain engines on the test bench use very little fuel, but people omit to tell you how much oil they use!

For one hour of flight including a climb of 500 meters at moderate revs., the Flea costs me 8 liters of fuel which means that I have used about 14 h.p. on the average. I should be delighted to see this amount of fuel last for an hour and a half; I am sure one will get to that point presently. Perhaps that will happen tomorrow let us be patient..

Too much oil? Yes, at first sight, but if you work it out the consumption of oil is not really terrific. In the petrol we put 6 percent of oil. let us think then that a small amount of this oil, highly

vaporized, is burnt with the petrol and adds something to the power; it is not entirely lost. And then the motor is continually lubricated with fresh oil; we have not to do the periodical emptying of the crank cases of oil which cause definite losses with other engines. In the two-stroke these losses go on all the time, but we always have fresh oil. And that is the reason why the world is better and the life longer.

The supplementary oiling is of the usual kind of all motorcycle engines; and so the wastage of oil is not very apparent. We might as well also recognize that four-stroke engines are more, and more being fed with a certain proportion of oil in the fuel.

SLOW RUNNING

The two-stroke engine runs badly at low throttle openings. That is a severe criticism and a valid one as regards surface vehicles. In aviation, what are we concerned with slow running? One flies always on a constant throttle and pulling.

BREAKDOWNS

The elements concerned are simple, accessible and can readily be taken apart. It is easy to discover the reason of a breakdown with a little thought.

BLUE BLOOD

The two-stroke engine does not permit of playing very much with the carburetor. When it is a matter of a rough and ready machine, any old mixture will suffice to nourish it. Our engine is more delicate than that. Of very high speed and very high compression it has delicate tastes; keep to the fuels and oils recommended by the maker. Now don't get mixed up between detonation and self-ignition.

Detonation. In this the explosive mixture explodes in every part at the same moment beyond a certain compression, and the motor knocks.

Self-Ignition. Here the explosive mixture catches alight aided by the heat of compression, but only at one portion of the explosion chamber which has remained too hot. Perhaps it is a little bit of carbon, which is incandescent or the red hot sparking plug point, or the base of a badly cooled piston. Self ignition is less brutal than detonation which heats up the motor and fatigues the material with the greatest rapidity. It can even cause the engine to stop without making it knock, giving the impression of a seizure of the piston.

That brings us to the question of sparking plugs; speed engines of high compression are very sensitive to their sparking plugs. They require cold plugs of which the electrodes, well withdrawn, are very thick and allow the beat of the point to escape to the body by their good conductability. In spite of this the fly wheel magneto allows for easy starts. Keep to the type of plug laid down by the maker; that is an absolute rule.

Personally I like plugs which can be taken apart, cleaned and renewed like the Lodge, H.45 or the A.30 which runs a bit warmer, but gives equal satisfaction. Don't go to extremes; if the plug is too cold oil may count on the point.

BUYING THE ENGINE

When I advise you to buy a new engine I have made the assumption that you have got the necessary 4,000 francs.

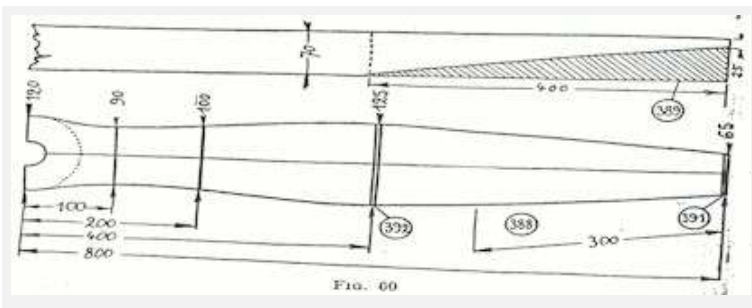
CHAPTER XII

THE AIRSCREW

The airscrew ... can one make it? Would it be better to buy it? We shall cut out ourselves a helicoid of twisted wood. Five hours work with a saw, a chisel and a hammer, to file and sandpaper, that is all. Calculation is easy, the drawing is easy, and construction as Follow me and you will soon see.

IN WOOD

The airscrew of the amateur is clearly in wood. Shall we make it of laminations glued against one another? The wood of an airscrew ought to be quite homogeneous, and its grain quite straight and closely followed. The large airscrew of a large aeroplane could not possibly be cut out from the trunk of a tree. The foot of the tree is heavier than the head, and the grain is a good deal twisted. Moreover, aviators who are always in a hurry could not wait until the whole mass of wood dried out. However, the airscrew manufacturers proceed in quite another manner; they cut the tree into thin slices, and dry it in a current of warm air. Then they glue these laminations together until the airscrew is as thick as they wish, only adding piece to piece where it is necessary. The airscrew then looks like a small staircase, and all that remains to be done is to plane away the steps, in order to get an excellent propeller out of it. Our little piece of woodwork will not look anything like that. We shall cut our airscrew out of a slab of walnut or beech, bought in the city. Every carpenter or cartmaker of a village has in his stock good slabs of this kind, quite dry and probably covered with the dust of ten years. Wood sellers are everywhere. A slab of wood about 0 meters 08 thick x 0 meters 18 wide x 2 meters long and cost about 25 francs. Choose one with the grain more or less straight, without any big knots and with no splits. A good deal of wood can be out away roughly, and this will take a carpenter about five minutes, and will cost you about five francs. Do not forget to give a tip to the workman, and to crack a few jokes with the master; perhaps we will finish by building himself a flea in the end.



THINNING DOWN

The first thing to do is to plane down your block of wood to a thickness of 70 mm. with both faces quite parallel and clean.

Draw a pencil line from end to end of it, following more or less the line of the grain. You will have brought along with you a template of plywood of 1.5 mm. out out according to 388. This template will do to trace the contour of one blade and then the other one, so that they are exactly the same. After the contour has been sawed all round, mark off the taper as in 389, and saw that off too. If after planing the slab of wood is not quite 70 mm. thick, mark it off as if it were 70 mm; the only difference will be that your taper will be less long.

GENERAL IDEAS

The airscrew is a sort of a small aeroplane, which is flying round in a circle. One blade of the airscrew is a sort of a little wing of varnished wood which has got the shape of a wing of an aeroplane, and which attacks the air at an incidence suitable to economic flight, which produces a thrust. Just like a wing, the blade of an airscrew can be worked out with polar curves and in flight it has got a trajectory, an angle of incidence, a lift, a drag, a loading per square metro, etc.

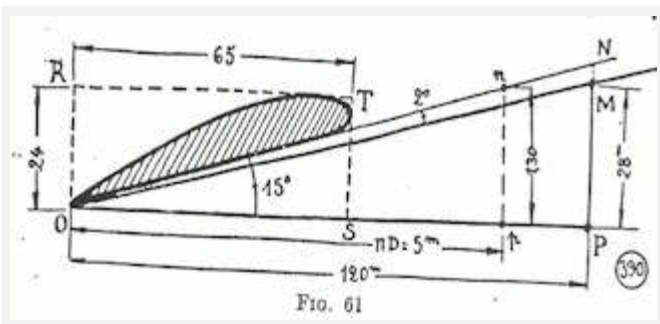
LET US FIRST DETERMINE THE TRAJECTORY

The aeroplane is flying at 100 kilometers an hour which therefore gives 28 meters per second. The airscrew is turned at 1,450 turns a minute when cruising, that is at 24 turns per second. The end of the blade at a diameter of about 1 meter 60, describes a circle of which the circumference is about 5 meters. $24 \text{ turns a second} \times 5 = 120 \text{ meters a second}$ for the speed of the tip.

Therefore, then, as you can see at 390 in Fig. 61 while the aeroplane is going forward from P to M, a distance of 28 meters, the tip of the airscrew has gone a distance of 120 meters, and the trajectory followed in flight by the blade of the airscrew is given by the line OM.

If the blade of the airscrew was twisted so that it lay exactly along this angle, it would hardly give any pull at all, because it would work on a nil angle of incidence; it is necessary to give it an angle of attack, a very small one it is true, because of its thick and curved profile, let us say for example 2 degrees.

Let us now take the angle $MON = 2 \text{ degrees}$, and let us mark out on the profile of the blade seen from the end, about 65 mm. wide. There you have exactly shown the incidence of the end of the blade on a plan of rotation to the airscrew. If you measure this angle with a protractor, you will find it about 15 degrees. A screw, a bolt or anything of that kind is always described by its diameter and thread or pitch. When you go to the ironmongers, you say, "give me a bolt of 6 mm. with a pitch of



PITCH

In one turn the airscrew of a diameter of 1 meter 60 describes a circle with a circumference of 5 meters. Along the line OP let us mark off Op=5 meters, and take the perpendicular pn. This perpendicular has a length of 1 meter 30. That tells us that if this airscrew was working in a solid (e.g. in butter) our screw would go forward 1 meter 30 cm. with each revolution; in other words its pitch is 1 meter 30. In point of fact, air being compressible and fluid, the airscrew does not go forward any more than 1 meter 10 cm. which is to say that it has a "slip" of about 15 percent.

Experience has shown that the best efficiency is got if you keep certain proportions between the diameter and the pitch so that the pitch is 80 percent to 85 percent of the diameter. In our own case, we have pitch 1 meter 30, and a diameter of 1 meter 60 which equals 82 percent. We are, therefore, In the right proportion. This idea of pitch will allow us, after once we have marked off the end of the blade, to mark it also at half way along the blade.

MARKING OUT

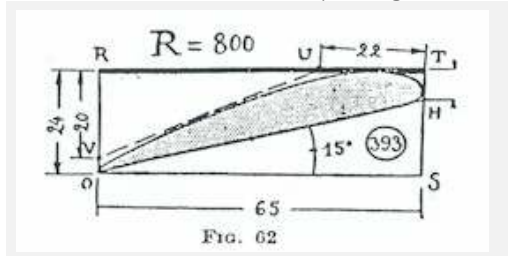
Only two sections of the airscrew really interest us; the section at the end 391 and the section at half the, radius 392. Between these two sections, which are the working portions of the blade,

speed is considerable, from 250 to 450 kilometers an hour. You can calculate by the formula $R=KSV^2$, but at these high speeds it ought rather to be V^3 .

Between the section at half way along the blade and the hub is the arm which form the working portion of the blade. It is hardly of interest to us except that it ensures solidity. Do not forget the centrifugal force, which may amount to 1,000 kilos.

The section here will be double convex, and so you will take off a little wood around the tracing; just enough to give it nicely rounded lines.

390 shows the section of the end of the blade inscribed in a rectangle OSRT, which is the section of our piece of wood when it has been planed down; the dimensions are shown in 393. By a similar sort of graphical analog we have at 394 (Fig. 63) $Op'=2$ meters 50 and $P'n'=1$ meter 30, that gives us OH which is the incidence half way along the blade, i.e. at a diameter of .8 meters. The angle is 27



degrees.

Now that the profiles of the wings have been worked out, we see that to cut out an airscrew really means cutting out some triangles in wood OSH and RVU. The points HVU are very clearly defined. Mark them off on the piece of wood as in 395, which you can mark, on the rounded portion between the half way point and the hub.

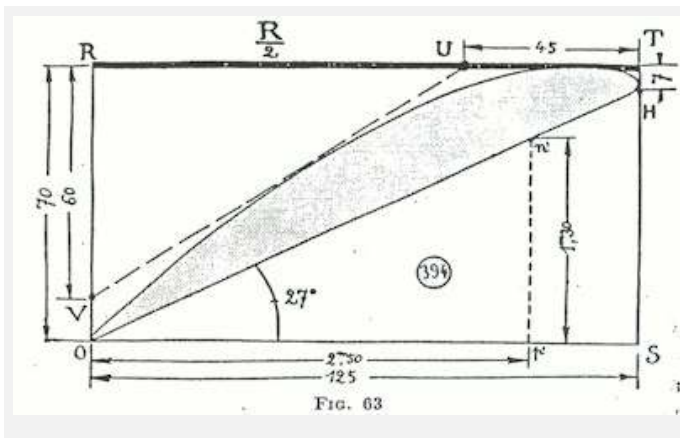
REMARKS

1. Do not forget which way the airscrew revolves When I talk of a right handed airscrew I mean one in which the pilot, when sitting in his seat, sees the screw revolving in the same sense as the hands of watch. That is what happens if you fit an ordinary motorcycle engine, and drive the airscrew by chain.

Those airscrews which are driven by gearing turn the opposite way, as is the case with the Aubier- Dunne. (Note that the two-stroke engine can be made to revolve either way, only changing some small portions of the magnetic flywheel.)

Be careful The error has already been made by others, and there have been amateurs who start up their airscrew only to see the machine go backwards while the wind blows into the starter's face, while he is left absolutely astounded in front of his useless shocks.

2. Before you mark it out you will have made certain that the face RT of the block is quite flat and well-planed and smoothed, because in effect it is the baseline of our drawing.



CUTTING OUT

If the amateur, too, is not very handy, there is an easy and prudent method of cutting away large masses of wood without going too deep, and this consists in sawing through the corners which we have got to cut off OSH RVU by saw cuts about 30 mm. apart and 15 mm. deep at the deepest. Then you can cut out these little slips of wood with a chisel of 20 mm. with little blows of the mallet (Fig. 64).

If I were you I would give the sawing out of this to a friend, telling him that he is contributing to the progress of aviation. Watch him carefully, so that his saw cuts do not go beyond the mark. By the end of the day you will have avoided a curvature to your own spine! You will now have the piece 397. Cut out in this way the end of the wood is, so to speak, twisted or deformed. Plane off neatly with small plane 398 (you will also want to have a spoke shave.), the lower faces OH of the two blades, flat and regular as possible. It is rather a good thing to cross your strokes of your plane at an angle. Then check the incidence at the half way point and at the end of the blade in relationship to your hub by lining up two rules, which should be quite parallel 401 the one blocked by a template of steel cut to the angle desired, i.e. 15 degrees at the end and 27 degrees at midway, see 402.

Once this has been done round off the angles 403 with your spokeshave and your plane, being careful to leave the marked spots X 403. The angles are rather more rounded towards the hub; you first of all plane, and then you use the spokeshave, then the rasp, then the half roomed bastard file, so that you gradually get your angles changing into curves and working into the hub.

At an equal distance from the hub a template of cardboard 404 will mark off the two ends of the blade, which can be rounded with a rasp and filed. A saw cut 405, about 2 mm. deep across the middle of the hub and perpendicular to the axis, will permit the balance to be decided exactly.

BALANCE

If you place this saw out on the blade of a knife, you will very soon see which blade is heavier than the other, and make them quite equal by planing the back face of the heavy one (do not touch the flat lower face). When this is done, turn the airscrew end for end on the knife. Exactly the same? Good.

VARNISHING

With sandpaper, smooth up. all the surfaces, crossing your strokes. Often smooth it with the hand, and look at it towards the light. This will show you whether there are high spots still left. Keep an eye always on its balance. Finish off with paper which is finer and finer, stuck over a block of wood or cork. Any sort of paint or enamel or varnish will do to protect the wood, such as Ripolin, Duco, etc., which one applies with a brush, or better still a pressure gun; three layers, with six or eight hours between each layer.

REINFORCEMENT

If you are going to fly through the rain or along the seashore, or even in very high grass damp with the dew, of morning, drops of water or grains of sand will be just like so many little bullets, which will eat away the leading edge of your airscrew for the last 20 cm. towards the tip.

Thinking ahead of that, I have made the design of the contour of the blade in such a way that the leading edge is a straight line, so that if you wish you can easily apply a little armoring of aluminum 406 of .5 mm. material about 200 mm. long, bend it, let into the wood, and well fix on the blade with a binding before you rivet it with aluminum rod of 3 mm. 30 mm. apart. Smooth up this surface quite accurately.

RIGGING

The airscrew which has been well balanced can still vibrate in flight if the blades have not got the same incidence.

Put your machine in a flying position. Stick a ruler 407 on two petrol cans behind the airscrew at about 150 mm. from the end. As you turn the airscrew round, you place this ruler exactly parallel to the plan of rotation, the middle of the ruler being at the vertical of the axis of the hub. With piece of celluloid 408 which you have marked off in angles, you can measure the incidence of the blades. Turn the airscrew gently end for end without moving anything else. Is the other blade the same distance from the ruler? Has it got the same angle? If there is only a little difference, you call bring it back again by tightening more or less the bolts of the hub. If there is a considerable distance, you will have to file or plane discreetly the face 409, which carries the plate of the shaft.

Hub

It would be a very good thing if the hub of airscrews for this light aviation were of all agreed pattern, so that the amateurs could change their screws with one another, or lend one to a comrade in case of need. I propose the one shown in drawing 410 (Fig 66). It is a simple plate with a boss of 15 mm. which centers the hub. The eight bolts of 8 mm. do the rest. A complete hub is quite useless. But will the human mind accept this simplification? I really have no illusions about it. However, it is the hub which I designed for Monsieur Dunne, our own patron, and one which he asked me to make.

DRILLING

At the last moment, just before you varnish it, you can drill your holes. You will have to mark out quite carefully the circles marking the central hole and the ring of bolt holes. The central hole for the axis is drilled with holes with a bit and brace of 7 mm. so that the holes touch one another.

A small wood chisel will cut out the inside bit by bit. With a gouge you can make the hole round, and with a half, round rasp you should adjust the diameter of the boss to the hub. The hub plate will serve to mark out the spots of the bolts. All this must be very exactly balanced on the saw cut 405. The holes will be marked out on the fibers of the wood in such a way to cut them as little as possible. If you have only got a hand drill, the eye of a helper and a little T square will assist you to keep the brace perpendicular. Drill half from one side, and then half from the other. Start with a bit of 2 mm. and then gradually increase it to 8.5 mm. The airscrew when finished weighs 3 kilos. . . . Do not be frightened by this long chapter about what is really a very simple job; the explanations are infinitely more complicated than the work itself. Because I have had to tell you everything in detail, I appear to be very long winded, but if you will read these pages through several times, you will see how easy it is, and that there is no real difficulty.

Work slowly and carefully. Think out your acts. Follow the order given exactly. Do not think that you have not sufficient skill. Have the pluck to start, and you will be successful at the first time of asking. You will then be convinced that this job of cutting out the airscrew is a jolly nice little piece of work.

CHAPTER XIII

MANAGEMENT OF THE ENGINE

Follow the maker's instructions to the letter regarding the petrol and oil which should be used even when you have become an expert; the maker will always know better than you which is the most hygienic mixture to keep his infant in the beat of health.

STARTING-UP

Open the petrol and oil taps. Flood the carburetor once only. The aeroplane is anchored by the T of the wheels

to a stake firmly fixed in the ground. Turning it in its direction of rotation; firmly grip the propeller blade with both hands 40 cms. from its axis and swing it powerfully, stepping clear at the same time, and taking care not to slip or fall forward. You will practice this maneuver in fact many times with the contact switch off. It appears to be difficult. It would be if one did it timidly. It is not when one "goes at it."

Do not repeatedly flood with petrol. Always turn the propeller backwards gently to get it to the starting position, because the magneto sparks very easily. You have perhaps got the mixture too rich (open the decompressor and), turn the propeller backwards for some time, with the throttle full open. When running let the engine warm up for a time. Study carefully the maker's instructions.

Throttled down too much, the engine is not in harmony with the propeller: there is vibration. Keep the engine turning briskly to avoid vibration: about 700 revolutions p.m. of propeller. Set the throttle to obtain the desired slow running at once when the throttle lever is brought back. You will not then fear stopping the engine involuntarily.

Sit in the machine. Open the throttle progressively to the maximum and note the speed on the revolution indicator.

CARBURATION

Remember that it is a mistake to try to economize petrol by fitting a jet which is too small. The engine will get hot and will age quickly. You economize a pennyworth of petrol; you pave the way for a 10 franc overhaul, if not an accident.

As soon as you are up, reduce the throttle by a third. This will only reduce the horse power by two or three. There is plenty of power left to climb honestly. You are running at perhaps 1,450 r.p.m. of the airscrew. Once at your desired height, reduce throttle again for cruising. Level out your machine to stop climbing: you increase in speed. There is less resistance from the propeller. The engine races a little: 1,400 to 1,450 r.p.m. That will do nicely.

For an attempt to climb to a great height, choose a cool day, 15 degrees c. at the most (and a clear sky so as not to get thrown about). In warm weather 25 to 30 avoid full throttle at steep climbing angles keep down the speed. The engine lacks air for keeping properly cool. Hold a reserve of speed.

I know that my engine is capable of turning at full throttle without inconvenience, but I adopt the principle that the best aeroplane, deprived of its engine, becomes a dangerous hulk. By treating my engine with care Aviation will never give me any hard knocks.

LANDING

Close the throttle completely, then open it a little, very little. Over suitable land do not fail to practice often the descent with the propeller stopped. After landing, remove the plugs: dripping oil will not dirty them and imprudent people touching your machine will be out of danger if they try to start your engine when your back is turned. In flight, there is no risk of dirty plugs.

STOPPAGES AND DIFFICULTIES

The maker will have given you an instruction book in which you will find a solution to all the difficulties possible.

In flight, the speed of the propeller suddenly begins to slacken: 1,450-1,400-1,350-1,300. . . . You are losing height. A stop is expected. There is one prompt maneuver which will probably save the situation: Throttle down at once. The engine has perhaps over heated (defective oiling, plugs too hot) or else the petrol is not flowing in sufficiently, etc... You will come down less quickly than if the propeller was stopped. At the last moment, if it becomes imperative to land, you may get the help of a last spurt of the engine. Generally, since you have reduced the speed slightly, the engine picks up again and you are able to complete your flight at reduced speed. Frequently go over your machine and engine, spanner in hand. Fixed and box spanners are preferable to adjustable spanners. Clean the fuselage with a rag dipped in paraffin, make everything like new after each flight. Oil everything there is to oil, not forgetting the wheels and especially the backrollers which, since they turn very quickly, soon dry up. Watch also the wear of their axles 102, of which you have a spare. It would not do for this to break in flight and thus deprive you of the rudder. . . !

It may so happen, for no apparent reason, that the engine refuses to start. The compression, although not perfect, seems passable. You exhaust yourself in swinging the propeller. Each time, the engine sparks but does not start up. You have checked every thing: sparking, carburation.

You must be lacking in oil and beginning to seize up. Dismantle the cylinders. Decarbonize; clean cylinder heads and pistons. Free the piston rings which are perhaps stuck. Repolish the piston skirts if the metal is rough. Verify the oiling system. A visible oil dripper at the outlet of the oil tank is very useful. It may so happen also that the platinum points of the make and break of the magneto have seized up on their fiber sleeve which may be swollen by dampness. Reamer this out, a very little, with a metal rod covered with a strip of emery cloth.

In the tool box you will carry the following tools and accessories:

1 sparking plug spanner, 2 sparking plugs with their washers.

1 adjustable spanner "crescent" type, 20 mm. capacity.

1 adjustable spanner of the smallest type.

1 spanner of 14 mm. (nuts holding base of cylinders) 1 screwdriver, 1 flat file, fine grade, 1 rat's tail file.

1 box (for screws, nails, nuts of 5 and 6 mm.).

1 set of jets (Nos. 180, 200, 220, 240 and 260). Rubber tubing, string, wire 1 mm. 6 spare piston rings. Emery cloth, sand paper, 1 cork. A 1/2-liter measure, the funnel.

A stake made of steel rod 8 x 200, pointed at one end and with a ring at the other, also a 10 foot rope 6 mm. thick for anchoring to the ground.

1 clean rag and a newspaper, 1 oil can. Total weight 2 kilos (4.4 lbs.).

For a long journey: maps and . . . food and drink. One flies badly on an empty stomach.

SECURITY

Perhaps you are not much of an athlete, or you may be past the stage of adapting yourself easily. At forty, one's reflexes are not as sharp as at eighteen. . . . The Flea is docile . . . but you are perhaps clumsy, careless or a madman. Also Nature, averse to progress, is there waiting to catch you out: A molehill rises in front of you, monstrous, during the night; an unsuspected paving stone; a rabbit hole.

Running quietly along, the machine suddenly hits some obstacle; not even hard enough to capsize it.

But you, poor fool, owing to your speed, you go and flatten your face up against the pylon struts or against the petrol tap.

The incident becomes an accident.

A belt would have avoided it for you.

In flight, in a strong gusty wind, you run the risk of being thrown out of your machine.

You must form one unit with It.

Did you know that most touring planes lack belts and strong handles to grip? They are all sold as though one could never get tossed about! For almost nothing, aviators go and knock their heads against the instrument panel. Idiots! I tell you.

Well then have a strong belt fixed to the side stays of the back of the seat. But let it be a special aviation belt which has a quick release in case of a fall into the sea for instance. A belt, a petrol filter and extremely strong landing gear are the aviator's safeguards. When applied to the Flea, they render aviation safer than motoring.

You must also have: A flying helmet.

A rev. counter for the engine. An airspeed indicator.

With these, with your safety belt, your petrol filter and Your FLYING FLEA you have nothing to fear.

CHAPTER XIV

HOW TO FLY THE FLEA PILOTING

The Flea flies on its own.

It cannot side slip.

It cannot get into a spin. It cannot stall.

It can fly at angles beyond the star.

To learn to pilot a plane consists of learning to turn correctly, and since the Flea is unable to turn otherwise than correctly, one pilots it without previous training.

There is no need to guess in advance, to foresee the evolutions. To pilot it is merely an act of supervision, and of obeying your reactions. To pilot the Flying Flea is infinitely easier than to drive a motor car.

You have the control stick in your hand. In the air, when you move it about, the whole machine moves about in a similar direction. No mistake is possible. You cannot make a mistake, and variations of speed do not alter in any way the control.

To learn to pilot, under these conditions is merely a matter of getting accustomed to a new exercise, for which your reactions are already formed. What you lack, is knowledge of the amount of control to use and coolness in its application.

In fact, you have not yet got "air sense."

I have said that I am essentially a man in the street, very enthusiastic, yes, but terribly afraid. I have a horror of taking risks and of uncertainty. I have just been making trials with my machine and bringing it up to scratch. I was faced with the unknown. It might possibly not be stable, might be 49 catastrophic." . . . I had already crashed.

I have never yet hurt myself. This proves that I am exceedingly prudent.

I have left the ground, flown, turned, and countered bumps. It has been necessary for me to learn these maneuvers by myself. Nobody could indicate things to me, naturally Well, I felt I could pilot at the end of an hour's flight. If I had had an instructor I would have been a pilot at the end of five minutes.

The following is in my opinion the most rational method for learning to fly prudently and quickly on the new type of aeroplane which is the Flying Flea.

HOW ONE LEARNS TO PILOT THE FLEA

METHOD

A. In no wind:

- (1)Taxing along the ground.
- (2)Take offs, and landings.
- (3) Straight flights, watching the instruments.
- (4) Flights as a passenger.

(5) First real flight, turning.

B. In wind:

(6) Counteracting bumps.

(7) Safety measures

A. In no wind. No wind at all to start with. Dominating the camp one needs a mast, or a bamboo pole, or a long straight branch which holds at its summit a cloth streamer about 40 mm. wide and about 2 meters long. Wait for a time when the streamer is at an angle of less than 45° and never make any attempt in a wind which is stronger than in 413 i.e. no, wind.

414=1-2 meters per sec.

415=limit of first flights.

416=Fair wind, it will be bumpy.

417=Stay on the ground.

The hazy times of the day, that is to say the morning and the evening, are favorable moments. If there is a breeze at all you face into the wind and gather speed into the wind. The beacons 418 (consisting of a newspaper which is tied with string round the branch of a tree, in the shape of a bouquet) indicate bad parts of the ground and the limits of the ground.

1. On the first outing one should merely taxi. A number of runs backwards and forwards. . . . Very slowly first of all, at a jog-trot, so as to accustom oneself to moving the throttle and steering on the ground. Slow down before turning round. One must have the wind either in front or behind. You must not taxi with the wind abeam. With the wind behind taxi very carefully, otherwise you may turn over. If throttled down too much, the engine vibrates, avoid this. Give enough throttle so as to be pulled along gently without vibration. It is quite certain that at the end of this first trial you will accelerate too much, for a second just to see what happens. Careful . . . Come on now! steady. You are not yet ready.

If there is the least gust of wind, the machine will want to swerve. Counteract it with the control stick. Keep a straight course.. The Flying Flea with wheels at the rear does not fear cross wind take offs.

2. Up till now, you have more or less got used to the throttle and the rudder. You have been motoring.

Today, speeding up your engine a little you are going, for the first time, to get a glimpse of an "aerial" sensation.

You run at a greater speed and the bumps on the ground are smoothed out. To move the control stick fore and aft is easier.. The steering is a little less exact, or rather is not quite the same movement. . . . You are running with your tail off the ground.

With the free front wing, the speed lifts up the back wing half of the Flea is in flight. Do you understand? The back of the machine, which is fixed, is a kind of trailer aeroplane, which takes off independently from the pulled aeroplane..

It is now up to you to take off with the pulled aeroplane, that is to say the front of the Flea, by pulling on its front wing.

You already know the attitude of flight of the machine because you have often taken your seat in its cockpit after having placed the tail on a jack about 20-25 cm. high; this placed your eyes, the engine and the horizon in the same horizontal plane.

If you left the Flea to its own devices at full speed, its tail would go up too much; you might break the propeller.

By pulling on the joystick, you hold it in the attitude of Right, that is with its engine on the horizon.

In contrast to aeroplanes, the Flying Flea cannot get into this attitude without having a certain speed, Thus it cannot turn over in spite of whatever you do.

There is no reason why you should not let it run along with the tail up, in flying position.

Bumps will make you bounce up, you are lightened you are almost in flight. Being impatient, you accelerate a little more it is done! You are flying. Throttle down slightly. Without moving anything else, you come back to the ground.

You have been working in calm weather. That is enough for today. Do not hasten with the matter. Go home.

ONE'S TOUCH IN THIS SPORT IS PERFECTED LESS BY PRACTICE ON THE TRAINING GROUND THAN BY MATURE REFLECTION WHEN RESTING. YOUR TRIALS WILL BE SHORT, AT INTERVALS OF ONE OR TWO DAYS.

Follow this sound advice and fill up your hours of inaction by touching up, servicing, cleaning and greasing, your good little machine.

3. Third Outing : Speed up your engine a little more. Amuse yourself by flying the whole length of the ground.

You want as calm weather as possible; that will enable you to fly in both directions, whereas if there was slight wind you would be unable like all aviators to take off with the wind behind you. By flying you will not be wearing out your landing gear.

Today, you are sufficiently trained to have time to cast a glance at your speedometer.

In future, instead of flying your machine, you will fly the air speed indicators I am not suggesting a bad habit. It can't be helped. It is the basis of my method.

FLYING BY INSTRUMENTS

Old pilots say that to acquire air sense one must pilot without instruments, one must get the feel of one's machine.

To learn a trade, one can get apprenticed at the age of ten in a workshop, fetch and carry for five years and finally, begin to use a file clumsily. One has acquired a "professional sense."

In a month, with the help of a good book, and a good instructor, you would have learned considerably more about it.

Our instructor never makes a mistake: it is the instrument, the air speed indicator. Sooner or later you will have to fly in misty weather, in the clouds. One must be able to pilot without visibility, i.e. by instrument.

Begin, therefore, at once. The famous "air sense" will come later. It is less urgent than actually flying!

Thus you notice that the machine leaves the ground when the air speed indicator shows 4, for example, but the aeroplane does not keep up. You release your pull slightly. It touches ground, but accelerates. It flies. The air speed indicator marks 5. It keeps in flight. Remember this speed and the position of the engine above the horizon: this is the angle of economic flying, that is to say the angle that you will usually keep at when climbing. Try and appreciate the sensation of this climbing flight. To cease flying you will let your hand give slightly, and reduce the speed of the engine. In spite of this the air speed indicator will read 7 or 8.

You are still held up, for the machine is now at full cruising speed. You are reaching the end of the ground. Throttle back the engine, completely but slowly, watching carefully the horizon in front

of you. You are coming down. Pull on the joystick to lessen the shock of contact with the ground. Gradually pull right back, as far as possible without going up again. It is the braking movement which pulls you up at 20 cm. from the ground just before your plane loses its grip of the air. Teach yourself not to lose your lift from any greater height, under penalty of a disagreeable shock. The loss of lift in the air takes place at the moment when the speed is so small and the machine so tilted, that the whole effect of the slot disappears. If you lost flying speed from the height of 1 meter you would plunge forward and risk running your nose into the ground and turning over. Before losing your lift, you can accelerate the engine. The wind from the propeller will preserve the slot effect and, if very tilted with the tail on the ground, the engine up in the air, the Flea with a span of 4 meters will drag along under full power at a speed of about 30 kilometers an hour. It will form a kite flying in the second regime, beyond the stall. . . . This is something which the author had not thought of in his calculations for an aeroplane weighing a hundred kilos. The fourth flight will allow you to master your machine. I repeat, fly by the air speed indicator. Take off at 4, accelerate at 5, fly at 7. Make the most of these journeys backwards and forwards in calm weather and manipulate the throttle during flight. Do not throttle down suddenly while in full flight. You would have the disagreeable sensation of tilting up and rising in spite of yourself. Throttle down slowly. Treat your engine gently. Your life is linked with its life. Having throttled down, let your hand give on the joystick so as to keep the air speed indicator at 6. Nothing is changed as regards the flying, but the rudder is easier to turn and you are descending.

REMARK

You will notice that having throttled down, the engine having slowed down, the machine is a poor glider. You will also note that it regains its flying qualities as soon as you accelerate slightly.

"How can this be," you think to yourself, "that I am able to fly along normally with 10-12 h.p. which indicates fairly good streamline qualities and that in gliding I push through the air like an old flat iron?"

This is simply because, when turning over very slowly, the propeller acts like the rotor of an autogiro, like a windmill with the brake on too much. It no longer attacks the air with its slicing action but opposes to the speed of the machine a complete disc having an effective diameter of 1 meter 60 that is to say a resistance to progress, a braking action of a surface which is virtually $R^2=2$ sq. meters.

When you practice flying with the propeller stopped, you will find once again your streamline qualities; the propeller now only opposes as a resistance its true surface which is approximately 12-13 sq. decimeters. When you throttle down, to descend, set your propeller speed to 1,100 revolutions per minute. The engine consumption is almost nothing: it is not pulling. The propeller is slicing its way through the air: it is "transparent."

Picking up again with the engine. Coming down with the engine ticking over slowly should you want to rise once more, open up the throttle. The air speed indicator changes to 7-8-9. . . . The machine accelerates but hardly rises again. Straighten it out therefore at the same time as you accelerate, and keep the air speed indicator at 6. Pull, on the joystick, with the air speed indicator at 6, you rise easily. Here you are 30 feet up! Does the "emptiness" frighten you? Have you never been in an aeroplane? Perhaps you have never been up in an aeroplane?

4. It is necessary that you should take a few passenger flights in an ordinary aeroplane. Let yourself be taken to a height of about 2,000 feet, like an ordinary package. You will watch with all your eyes! Choose a day when there is a breeze, with well defined clouds which are moving, so as to appreciate

the movement and thus not be surprised by it when you are alone with the controls in your own cockpit. If you follow my method, there is every chance that a single passenger flight in windy weather will give you a bad impression: "Good heaven no!! is this aviation?"

The second flight four or five days later, will remove this bad impression.

A third, so as to feel again certain confused sensations, would not be useless. One can fly for 40 francs. Thus you would expend 120 francs which would be well worth while, but that would be quite enough. You no longer need aviation. It is between us two now.

5. You have got used to height. You do a straight flight perfectly.

Your reactions on the control stick are gentle and progressive. No more jerks. The engine drones along, in fact you no longer think about it. The machine glides, lightly, obediently. One eye on the air speed indicator which is at 6 to 7, while the other eye looks below, contemptuously on the fields with cows! Your shadow follows you or precedes you . . . the horizon is very different seen from above than seen from below. . . .

. . . and you have a smile on your face. It is so simple that it is too simple. The control stick, the air speed indicator, the throttle. That's all!

A sport for a woman! The woman?

. . . Her light weight (don't make me say her small brain) invites her particularly to the sport of the air! A woman's strength is in her intuition, her spontaneity, the speed of her reactions.

Ladies, the Flying Flea is made for you. It obeys perfectly logical reactions because its controls are logical; even in a storm, you will not make the wrong movement and will always save the situation. Aviation is the feminine sport par excellence. The mechanism is reduced to a minimum and the necessary qualities are less mechanical understanding than promptitude and subtle intuition of reaction.

To fly is a fine gesture, an elegant affair; who better than a woman, could appreciate its aestheticism, its lightness, the rhythm of its evolutions?

There is nothing better than that. To fly! Live like a fairy!

To be a bird . . . in a paradise!

The control stick, the air speed indicator, the throttle. It is so simple that it is too simple! Your reactions are already developed. You are ready for the turn. Fill up with petrol. Get to a height double that of the highest obstacle.

Rise to about 300 feet.

Carry the control stick over to the left about 4 or 5 inches. The machine leans over very slightly.

Do not get worried by this sensation of tilting over towards the void. It is the beginning of the turn if you are going slowly.

Bank over, remain banked over, and watch the air speed indicator. Hold it at 5 to 6 just as though you were horizontal, flying normally. The countryside passes by in front of the engine, towards the right. You are turning. And that is all there is to it!

You can now stay up in the air as long as the tank contains any petrol.

Avoid banking over too much to start with. Make a wide turn.

To turn to the left, to turn to the right, is about the same. There is a slight difference, due to the direction of rotation of the propeller. It is hardly noticeable.

To come back to the horizontal and stop turning, carry the control stick over to the opposite direction, gently, until you are straight, watching the air speed indicator the whole time. What does learning to pilot the Flying Flea consist of? It is to perform evolutions in all directions keeping the air speed indicator at 6. That is all (You must understand that this number 6 is only given as an

example so as to give a clearer idea. It may be quite different, it depends on the instrument you are using.)

Find me if you can in another heavier than air machine, a method which is easier than that of the Flying Flea for turning:

"BANK OVER AND KEEP THE AM SPEED INDICATOR AT 6."

This, either at 500 feet or at 50, or at 5. You can even turn very abruptly just clear of the ground because the Flea cannot stall against your wish. In a very abrupt turn, after reaching an inclination of about 40', you must pull back the control stick so as to tighten up the turn, because then the wing and the rudder co-operate in their effect. This is merely as a reminder, because you will soon find this out for yourself. Before turning, make a note when flying normally which part of the engine is against the horizon. Move the rudder, the machine banks over and turns: your speed will remain correct if the same part of the engine remains outlined against the horizon.

There are a number of pilots who, after thirty hours of flight, will turn banking over too much or too little slipping towards the inside or towards the outside of the turn. How many experienced pilots now only turn vertically? They no longer know how to turn normally.

Your first turn will be just as correct as the turn of an old professional. A bubble bank indicator would prove it to you irrefutably. (I have verified it.) This air sense of aviators! the Flying Flea does not even need it.

THE DANGER OF THE TURN

When one turns, an extra force helps to strain the machine, i.e. centrifugal force.

The more abrupt the turn, the greater the centrifugal force. You notice this by the feeling that you weigh heavier in your seat.

The engine also becomes heavier and everything else at the same time. It is the stays which have to resist the weight.

It is for this reason that, when banked at an angle of 64' you weigh twice your weight, in a theoretical turn.

At 800, you weigh six times your weight.

Over 80' you run a risk of parting with your wings. A vertical turn, pulling hard on the control stick is an acrobatic absurdity, just like turning in a car on two wheels.

A turn at 40' to 50' is amply sufficient for all usual evolutions.

When the Flying Flea is feeling the strain, it pulls harder on the control stick. For example: In normal flight, the control stick has a pull at the hand of about 7 lbs..

In a turn at 64', when the weight is doubled, the control stick pulls 7×2 equals 14 lbs.

In a turn at 80', the control stick pulls 42 lbs.

You are not so ham fisted that you cannot differentiate between 14 and 42 lbs.! You have been warned! It is up to you to yield. You are the only one responsible for exaggerated maneuvers. The same applies for a dive and a zoom. The same thing applies in squally weather.

If the Flying flea does break its wings, it will be you who will have broken it voluntarily.

B. In Wind. You will already have had, several times, small gusts of wind which will have influenced your flight.

To bank makes you turn to turn makes you bank. The difference between the two maneuvers, banking

and turning, is seen by the control stick, which, carried sideways,

1. In a turn is pulled back more as the turn is more abrupt.
2. In regaining one's balance is pushed forward rather more.

To correct bumps, therefore, amounts to turning, or banking. The movement has some resemblance to the control of a bicycle with just this difference.., that the latter is not stable whereas the Flea is stable.

A gust of wind under the wing makes it heel over. You at once start on a turn. Your reaction is to move the rudder so as to turn in the opposite directions? You have made a swerve without knowing it. You are once more set on your course.

The two movements, stabilization and turning are closely linked. There is no crossing of controls to be afraid of, no possibility of an incorrect movement. You cannot make a mistake:

YOU ARE A PILOT.

To learn to Pilot is thus nothing more than practice In giving the right strength of movement on the joy stick so as to bring back the machine to its chosen course.

General rule : Just as on an aeroplane, the less you worry it the better the Flea will fly.-"Leave it alone!" Pierre Collin would say to me when I tried to "feel" the Potez. And, in fact, when I left it alone, it gained height.

Be gentle in your movements: the movements of the joystick are in measurements of inches. At a slow speed, at the beginning of a flight, at the end of landing, one has to make big movements.

This is a habit quickly acquired.

ROUGH WEATHER

The wind may be slight on the ground and not be very gusty in the first few hundred feet. You rise to 1,000 or 1,600 feet. All of a sudden under a cloud gusts of wind hit you from the left, from the right, carry you up, push you down. You control nervously. You grow pale, perhaps your left hand clutches the cockpit side. . . . How is it going to end.? The engine roars, and stays shriek. . . . Try and keep cool! Clench your teeth. Are you a man or a little girl? This first contact with the wind is more impressive than dangerous. You can say to yourself that the game is not lost unless you leave go of the joystick. Obey your reactions and do not hurry them when reacting against the gusts. The span of the wing sways; let it come back on its own.

ENVOI

Here we must leave Mignet, proud that he had., introduced a new technique, that he has shown the possibilities of flight at low cost, that he has popularized

Sport of the Air.

His followers in France form a great body. Four hundred copies of the Flying Flea (or Pou-de-Ciel, as it is called in France) are under construction by amateurs and forty have flown correctly. They have formed an Amateur Association and by the strength of their numbers they have gained recognition by the State of the right to fly these small machines.

Here in England we fear no obstruction; we can confidently count on sympathy and assistance from the authorities. But we must organize ourselves as they have done in France, because Governments cannot deal with individuals each asking something different from his neighbor.

It is for this reason that the Air league of the British Empire has formed a "Pou Club" (keeping the French name in honor of the inventor) to help and encourage amateur constructors and all forms of cheap flying it may grow into something far bigger.

If you are interested by this book of and all it stands for, I invite you to get in touch with us to see if we can help you.

J. A. CHAMIER.

Air League of the British Empire,
19, Berkeley Street, London, W.I.

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APPENDIX

1 mm. = .03937 inch
10 mm = 1 cm. = .3937
100 cm = 1 m = 39.37
1000 m = 1 km. = 1,093 yds.. or .62 mile
1 sq. m = 10.76 sq. feet
1 metre per sec = 3.3 feet per sec
1 liter = 1.76 pints
5 liters = 1.1 gallons

1 mm. = .0394 inch
2 mm. = .0787 inch
3 mm. = .1181 inch
4 mm. = .1575 inch
5 mm. = .1969 inch
6 mm. = .2362 inch
7 mm. = . 2756 inch
8 mm. = . 3150 inch
9 mm. = .3543 inch
10 mm. = . 3937 inch

CONVERSION TABLES

To convert into Multiply by

mm. inch. 0.039

inch. mm. 25.4

kg. lbs. 2.205

lb. kg. 0.454

liter gal. 0.22

gal. liter 4.546

meter yard 1.094

yard meter 0.914

kilometer mile 0.621

mile kilometer. 1.609

meter per sec m.p.h. 2.24

m.p.h. meter per sec. 0.447

Gauges

10 gauge (ISW) = .128 inch = 3.25 mm.

11 gauge (ISW) = .116 inch = 2.95 mm.

12 gauge (ISW) = .104 inch = 2.64 mm.

13 gauge (ISW) = .092 inch = 2.34 mm.

14 gauge (ISW) = .080 inch = 2.03 mm.

15 gauge (ISW) = .072 inch = 1.83 mm.

16 gauge (ISW) = .064 inch = 1.63 mm.

17 gauge (ISW) = .056 inch = 1.42 mm.

18 gauge (ISW) = .048 inch = 1.22 mm.

19 gauge (ISW) = .040 inch = 1.02mm.

20 gauge (ISW) = .036 inch = .91 mm.

Bolts and Nuts (British Association Standards)

0 BA = 6 mm

1 BA = 5.3 mm

2 BA = 4.7 mm

3 BA = 4.1 mm

4 BA = 3.6 mm

5 BA = 3.2 mm

6 BA = 2.8 mm

7 BA = 2.5 mm

8 BA = 2.2 mm

9 BA = 1.9 mm

10 BA = 1.7 mm

BAROMETER READINGS

(average-corrected)

29.92 in = 760 mm. = 0 feet

28.86 in = 733 mm. = 1000 feet

27.82 in = 706 mm. = 2000 feet

26.81 in = 681 mm. = 3000 feet

25.84 in = 656 mm. = 4000 feet

24.89 in = 632 mm. = 5000 feet

NOTE:

Henri Mignet went on to design many successful airplane designs based on the concept of the HM-14 Flying Flea. His family in France are still involved in aviation and sell his updated plans.

However, you must contact them in French.

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17600 SAINT-ROMAIN-DE-BENET
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There are many videos of the various Mignet airplanes on youtube.

Here is a Playlist of Flying Flea Videos

Flying Flea Airplanes Past & Present

http://www.youtube.com/my_playlists?pi=0&ps=20&sf=&sa=0&dm=0&p=BE3DD3C837716A26

Should you decide to build make sure you use updated plans and welcome to “The Sport of the Air!”