A Study in Aviation Parachutes*

Research in a Neglected Field

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THE number of aviation fatalities to date exceeds 300. France alone has lost 39 military officers, or pilots, and as many civilian pilots. Official inquiry into the military accidents in France prove that 40 per cent of the victims fell more than 100 meters.

Fig. 1.

Fig. 2.

In order to reduce the number of fatalities, various tentative efforts have been made:

1. Improvement in the structural strength of the wings and the effective operation of the controls;
2. Study of the means for automatic stability of aeroplanes; and
3. Parachutes.

Progress in construction has certainly been fruitful; but still certain breakages of wings, though well constructed, remain inexplicable.

Automatic stability cannot be perfectly attained. The best we can hope for is a measure of security like that of an automobile—a security which depends upon the evenness of the course. But the first two provisions for safety are unavailing in certain accidents which are frequent in war; for example, when a projectile breaks a wing, a rudder or a control.

There remains the parachute as the aeroplane's organ of safety and having no other function. To adapt it to the aeroplane, the following conditions are essential:

1. When resting folded on the machine, it must not affect the flight nor greatly increase the weight;
2. Its unfolding must not be hindered by the aeroplane; and
3. Its unfolding must not entail inertia effects dangerous to the pilot or the suspension system.

The most tempting idea is to attach the parachute to the pilot so as to save him, while abandoning the aeroplane. This scheme, however, presents a capital disadvantage; the operation is risky and the pilot might

Fig. 6.

hesitate to perform it. It seems, therefore, most simple, certain and practicable to parachute the aeroplane as a whole.

In order to combine these various ideas practically, I have contrived, studied and realized, with the co-operation of MM. Sloan and Verdier, constructors, a parachute system, as shown in Figs. 1 and 2. We construct the parachute of extremely light material; we place it within the body of the machine, the heaviest part under the pilot; folded inside a tube which projects from the rear of the fuselage; we release it top first by aid of a

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little tractor parachute, normally closed, which at the will of the pilot, opens to the wind and draws forth the large parachute.

In order to obviate a too violent jerk, on the sudden opening of the large parachute, a jerk which might break the suspension cords or excessively jar the pilot, we have interposed between these cords and the aeroplane, a cable passing over a brake, to provide a suitable yielding or elasticity to the system. At a flight speed, for example, of 50 meters per second, a parachute of 7.75 meters radius would have an acceleration of 400 meters per second and a pull on the suspension exceeding 20 tons; where as with a suitable interposed brake the acceleration would be 30 and the pull 3 tons with a yielding of 14 meters. An acceleration of 400 is what a person would have after falling 20 meters and checking his fall within one half a

Fig. 3.

meter; an acceleration of 50 is what a person would have on falling only 2.5 meters with the same checking space of half a meter.

What are the practical limits of speed of fall and endurable retardation? As to the first, it is generally estimated that the speed of fall is of the same order as the speed of flight, especially in case of wing rupture. The swiftest racing machines have not exceeded 200 kilometers per hour, or 55 meters per second. We may then

Fig. 5.

take 50 meters per second as the upper limit of the speed of fall. As to the practical limit of retardation permissible, the studies of M. Broca show that the human frame can, without danger, support, in the direction of the spinal column, an acceleration equal to 10 times that of gravity.

On the other hand, it seems unnecessary to strike the ground with an insignificant velocity, if the impact be suitably provided for. If on reaching the ground, the pilot can check his speed through a sufficient space with constant resistance, he will sustain a retardation which, if it does not exceed 100 meter seconds in the direction of his spinal column, need not subject him to any risk. A person who jumps from an elevation of 2.1 meters reaches the ground with the same velocity as our supposed parachute (6.5 meter seconds). It suffices that the yielding

Fig. 7.

space be 0.21 meters in order that the retardation may be 100. But this is an exercise which can be endured by everybody.

The acceleration due to the pull of the parachute on opening is proportionate in value to the speed of unfolding. It seems probable that a large parachute attached directly to an aeroplane would be dangerous, whatever its structural strength or the efficiency of its unfolding mechanism. But with a yielding brake, the acceleration need not exceed 50 meters per second. Also by a device for causing the parachute to unfold gradually, the pull on its cable can be sufficiently reduced. It is,

however, necessary to add to the brake mechanism a shock absorber to prevent breakage of the suspension system by reason of its inertia. This absorber may be made of rubber or plastic material, for it need not have much spring.

Fig. 4.

Instead of the brake, an elastic cable might be used; but this would be quite heavy, even if made of rubber, and still heavier if made of steel springs. Computation shows that a rubber cable 50 centimeters square in cross-section, and 16 meters long in its state of rest, would serve the purpose and would weigh about 8 kilograms.

The minimum altitude of fall within which the foregoing parachutes would work practically is estimated to be within 100 meters.

Pilot Parachutes.—The foregoing considerations apply also to parachutes for lowering the pilot alone. It is, however, easier with these to avoid the dangerous effects of acceleration by having the parachute to unfold gradually, and by employing an elastic suspension whose weight would not be excessive.

The difficulty of preventing the parachute from striking certain parts of the apparatus, the rudders in particular, is not insuperable. Fig. 3 represents an arrangement which would be able to operate successfully. The seat to which the pilot is attached is held to the aeroplane by a flange arranged on its back, and is attached by a bolt to the lever which actuates the releasing mechanism of the tractor parachute. The suspension system is attached by a cable to the upper part of the seat through an intervening brake, the cable itself passing round from the tail without touching the rudders. When the pilot actuates this lever the bolt detaches the front of the seat, and this rocks about the flange of the back, under the pull of

Fig. 8.

Fig. 9.

the parachute, and thus quits the aeroplane in good condition.

DETAILED DESCRIPTION OF THE COUADE-SLOAN PARACHUTE FOR A MONOPLANE OF FIFTY KILOGRAMMES.

Parachute.—The parachute is of Japanese pongee silk weighing 20 grammes per square meter. It is composed of 54 sections joined together by 54 double seams. The 54 suspension cords are of hemp, 2.5 millimeters in diameter and each capable of resisting 100 kilogrammes. They pass through the seams and are fastened to the periphery of a piece of sheet iron occupying the center of the hole. At their lower extremities, they join to a steel suspension

piece from which run two metallic cables, each of 2,400 kilogrammes tensile strength, which wind on the axle of the brake. The top center piece is united to the suspension piece by a cable *AB* (Fig. 4) of convenient length, designed to facilitate the unfolding.

The brake is very important and must be light and very strong, since it should absorb 30,000 kilogrammes in 0.7 seconds. We have anticipated employing three kinds of brakes from which, after trial, we shall choose the best.

1. *Brake absorbing the work by friction.*—All the types of brakes or clutches employed in automobiles can be used. For example, the brake may be composed of a

Fig. 10.

steel axle flanked by two steel drums. These drums rub against several rows of friction blocks united by metallic cables tightened by springs (Fig. 5). The brake is double and fixed to the aeroplane as shown in Fig. 6.

The work is transformed into heat, 30,000 kilogrammes corresponding to 700 calories. It suffices, therefore, to raise to a temperature of 350 deg. Cent., 2 kilogrammes of friction parts.

2. *Brake absorbing the work by the action of a tool paring material from a piece ad hoc.*—The work of tools is an element well known and of great regularity. A brake based on this principle will require repair after each operation, but this matters little. According to the studies of Schlesinger, it suffices, in order to absorb

30,000 kilogrammes, to produce 20 grammes of iron filings. The heating will naturally be considerable. This brake can therefore be very light.

3. *Hydraulic Brake.*—This brake is arranged like a cannon brake. In order suitably to amplify its displacement, we have devised the following contrivance Fig. 7. The axle consists of a tube turning in two bearings, and serves at the same time as a brake cylinder. Two pistons threaded oppositely traverse the opposite halves of the cylinder as shown, and slide without rotation along a fixed polygonal bar. This bar, as shown in cross-section, has grooves so formed as to cause a progressive flow of the liquid as in a cannon brake. This brake has all the regularity desirable; its only inconvenience is its weight.

TRACTOR.

The tractor, Fig. 8, is a parachute 0.6 meters in radius, made in 8 pieces, and provided with 8 ribs which tend to spring open. The suspension cords, 1 meter in length, are attached to the center piece of the large parachute. This tractor caps the top of the principal parachute within the tube, as shown in Fig. 1.

The cap or external tractor.—To the top of the preceding tractor is attached what we call the cap, Fig. 9, consisting of two very light semi-cylindrical snap lids hinged together elastically and clasping the end of the tube. Tiny cords hold the cap closed. They can be broken simultaneously by a violent jerk of two cables attached to a lever operated by the hand of the pilot.

Release of the system. Unfolding of the parachute.—When the attachments are broken, the cap opens and draws the tractor out of the tube, which requires very little effort. This in turn opens by the elasticity of its ribs and the rush of air, and with considerable force draws the large parachute out of the tube.

When the parachute is first unfurled, its suspension cords measure 15 meters, Fig. 4. They are held together by a band, *B*, at 3 or 4 meters from their point of attachment, Fig. 10. This band can be cut by a ring forming a guillotine held to the body of the apparatus by a little cord 12 meters long. It is actually cut when the cable has uncoiled from the brake one meter, whereupon the opening of the parachute is completed.

This arrangement supports the aeroplane by the tail, and lets it down to the ground motor first. During the descent, which may last several minutes, if the fall be great, the pilot will have time to climb, by means easy to negotiate, all the way up to the suspension system and hang there. He will thus reach the earth after the aeroplane, and without velocity so to speak.

It were preferable, perhaps, to let down the aeroplane in a horizontal position, in order to profit by the shock absorption of its landing gear. The best means to achieve this will be to fix the brake, not to the aeroplane, but to the parachute suspension, and to attach the cable leading from the brake to the upper strut of the aeroplane, Figs. 11 and 12. During normal flight, a part of this cable would be inside the aeroplane.

DEMONSTRATIVE EXPERIMENTS AND OPERATIVE TESTS.

1. Demonstrative experiments with a parachute have no real value unless made with full scale apparatus of full weight falling, and operating under the severest conditions, that is to say when the fall attains a considerable velocity, say 40 to 50 meters a second. To this end the aeroplane can be attached to a free balloon by means of

Fig. 11.

Fig. 12.

a mechanism capable of being opened by the pull of a cable *C* (Figs. 11 and 12). This cable may be so arranged as to uncoil easily from the ground to which its end is fastened.

2. Experiments on reduced models are less conclusive; still they are interesting and easy to perform. They will presently be made from the second platform of the Eiffel Tower, on a model of one fifth scale, weighing 20 kilogrammes, giving the same speed of fall (6.5 meters) as the real model. The brake will be adjusted to 100 kilogrammes and give 50 meter seconds as the acceleration, with a fall of 45 meters; the speed of descent will be 30 meter seconds, and there will still remain 70 meters for the working of the apparatus.

Forest Fires

DURING 1913 the forces on the national forests fought 4,520 fires, or nearly twice as many as started in 1912, the best year the forests have ever had.

Notwithstanding the great increase in the number of fires, Forester Graves considers that the showing made by the forest service was quite as favorable as that in the preceding year, because the damage done and the costs of fire fighting were no greater proportionately than in 1912. In both years practically 50 per cent of all fires were detected and extinguished before they burned over a quarter of an acre, and 25 per cent of both years' fires were put out before they covered 10 acres. Of last year's fires, 3,278, or considerably more than the whole number of fires in 1912, were confined to areas of less than 10 acres, and in 1,080 additional fires less than \$100 damage was done by each. In only 25 fires did the damage amount to \$1,000.

The aggregate loss in timber is estimated at nearly 59,000,000 board feet, valued at about \$82,000, and the damage to young growth and forage is estimated at about \$110,000, making a total of about \$192,000. About 18 per cent of this loss, however, was incurred on private lands within the forests where 16 per cent of the fires had their origin.

One encouraging feature is that the total number of fires set by railroad locomotives was scarcely more than in the preceding year and represented only 12 per cent of all fires, as against nearly 19 per cent in 1912; also the proportion set by sawmills and other engines in the woods was considerably less than in 1912. This indicates very plainly, Mr. Graves says, that the public is awakening to the need of spark arresters and care with engines in the woods.

Looking for the reason of the increase in number of fires, the forester finds three main causes:

First of all, the unprecedented electric storms which swept the whole State of California at the end of a long dry season, and set, almost simultaneously, about 700 fires. The 804 fires set by lightning in California formed nearly 50 per cent of the 1,628 fires on the national forests of the State from all causes, and were more than half of the 1,571 lightning-set fires in all the 21 States reporting.

In the second place, there were 757 fires which started outside the forests, of which 644 were stopped by the government's fire fighters before they reached the forest

boundaries, as against 424 which started on outside areas in 1912. However, the proportion of such fires to all those which the service battled with was about the same for 1912 and 1913.

The other increased cause of fires was incendiarism, but this increase was confined to three States, Arkansas, California and Oregon, all others showing a marked decrease. Of the 452 incendiary fires, 128 were in Arkansas, 133 in California, and 142 in Oregon, where two brothers were known to have set 72 on one forest alone. These two and other incendiaries were, of course, severely dealt with by the law. On the Arkansas forest, too, it has been assumed that the 351 fires classed under the general heading of "origin unknown" were mainly incendiary. In California, the incendiary fires are largely attributable to what is known as the "light-burning theory," which advances the argument that forests should be burned over frequently to prevent the accumulation of debris. The forest service considers this a pernicious theory because it scars the standing timber and thus reduces its value; it robs the forest soil of its ability to retain moisture, and effectually prevents the reproduction of the forest, since such fires destroy all tree seedlings before they have a chance to get a good start.

In 1912, lightning caused more fires than any other agency, followed closely by railroads, campers and incendiaries, in the order given. In 1913, however, the fires caused by lightning outnumbered the next nearest cause by more than three to one, but the order—railroads, campers and incendiaries—remained the same as in 1912. A considerable decrease in the proportion set by railroads and campers indicates, according to forest officers, a growing carefulness on the part of the general public.

Last year, as in 1912, California led all others in number of fires, this lead being natural because California has such a long dry season. It was followed by Arkansas, Arizona and Oregon, in the order named. Kansas, which had only one fire in 1912, escaped without any in 1913. North Dakota repeated its record of 1912 and had no fires on its one small forest. Not a single severe fire occurred during the year in District 4, which includes Utah, Nevada and southern Idaho, and in which a large proportion of the forests reported no fires at all.

There was proportionately greater loss on private lands within the forest boundaries than on the public lands. It is pointed out by the forest officers that these lands

cover approximately 11 per cent of the total area included within the forest boundaries, yet the area burned over on these private lands was more than 25 per cent of all. The forest service expended more than \$30,000 in protecting the private lands within the forests and lands adjacent to, and outside of the forests. In addition to this cost, services and supplies to the value of more than \$17,000 were contributed by co-operators for fire-fighting on these areas.

In the middle of the fire season, that is in July, the service had high hopes of small fire damage during 1913, and this hope kept up until the middle of September, when the fire season on the national forests ordinarily is about at an end. At that time there was less damage than had ever been recorded, and only 2,260 fires as against 2,470 in 1912, with about 60,000 acres burned as compared with 230,000 in 1912 and 780,000 in 1911. At the end of the month, however, the electric storms in California and one or two outbreaks of incendiarism changed the whole situation.

But even in the face of these difficulties, the fire-fighting force, with its plans and experience from preceding years, was able to cope with the situation. In California, in particular, it was as if a military leader, represented by the district forester at San Francisco, was holding, with a comparatively small number of men, or a mere skirmish force, a line of defense extending 750 miles in a north and south direction. This force received, as if from an attack by the heavy artillery of an opposing army, the electric storms, generally unaccompanied by rain, which played havoc all along the Sierras and the Coast Range. That the California force was able to cope with the situation was, according to Mr. Graves, an evidence of the efficiency of the organization.

Crawfish are so numerous in the black prairie soil of our Central States that they destroy great quantities of forage and interfere seriously with the development of cotton and corn. Experiments in exterminating these pests have been undertaken by the Biological Survey on a tract of 75 acres of pasture land near Muldon, Miss., on which an average of 10,000 crawfish holes were found to the acre. Under the old method of catching the animals by hand at night the cost varied from \$6 to \$10 per acre, but the Survey has devised a method of treatment with carbon bisulphid which reduces the cost to between \$1.75 and \$2.50 per acre.