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SUITABILITY OF THE AS 365 N DAUPHIN 2 TO OFF-SHORE MISSIONS

by

R. MOUILLE, Technical Deputy Director
Aerospatiale Helicopter Division

FIFTH EUROPEAN ROTORCRAFT AND POWERED LIFT AIRCRAFT FORUM
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1 - ABSTRACT

In the evolution process of the Dauphin 2 from the 365 C version to the 365 N version, Aerospatiale has aimed at better adapting this aircraft to the missions which it is capable of and among which off-shore missions rank first.

The evolution process that has led to the 365 N version involves the following aspects :

– *improved performance thanks to :*

- new main blades using new airfoils that consume less power both in hover and in cruise,
- more powerful Arriel engines with more efficient air intakes,
- a streamlined fuselage with a retracting landing gear for lower energy consumption in cruise,
- high capacity fuel tanks making long distance connections at sea possible without heavy, cumbersome, possibly parasitic drag inducing auxiliary tanks.

– *a new landing gear design,* which is now a tricycle unit with steering front wheels allowing easier alighting on a very narrow pad,

– *an improved cabin space* thanks to the elimination of the control tunnel of the 365 C and the larger baggage hold directly accessible from the cabin,

– *a fuselage - integrated emergency floatation gear* lighter in weight and giving no additional drag when folded,

– *a cabin nose* which both improves the elegance of the aircraft and makes the installation of a radar possible,

– *retractable footsteps* making embarking easier without creating parasitic drag.

Coupled with already existing features of the Dauphin such as :

– its corrosion - free, very reliable, easily inspected composite main rotor head and blades, and,

– its shrouded tail rotor or «fenestron» for easier flight maneuvers and alighting on narrow platforms and offering greater safety to platform personnel,

these evolutions have made the 365 N particularly well suited to off-shore missions and very economical in use.

2 - OFF-SHORE MISSIONS

It has appeared that the helicopter is an indispensable connection and transportation means for off-shore oil operations. The number of aircraft in operation is rising ceaselessly (fig. 1).

There is a wide range of helicopter types in operation today : 3 seaters, 5 to 6 seaters, 8 to 14 seaters, 20 to 30 seaters and even larger aircraft seating 30 to 40 people are being envisaged today, with tonnages ranging from 1200 kg to 10 tons and even 20 tons in the near future.

Obviously the aircraft that have been used so far for that purpose were not originally designed for it. These aircraft have mostly been designed for military roles and subsequently adapted to off-shore missions as well as possible.

Now these missions are very specific and the cost-effectiveness of the available material will be increased only if it is taken into account right from the very beginning of the design phase.

2.1 - DISTANCES COVERED

The distances to be covered by helicopter during off-shore missions vary with the operation areas. However *this distance tends to grow.* In fact with the intensification of the search for new energy sources and the improvement of deep water drilling techniques, oil drillings are done further and further away from coasts.

Moreover, aircraft are now used for inter-platform flights which can be arranged all the more easily as the aircraft has a long range.

This is why a *large capacity fuel tank and a maximum consumption reduction* are necessary. Unfortunately, off-shore mission aircraft are derived from military aircraft with a fuel capacity that has remained limited so far, making, it necessary to add auxiliary tanks that gnaw at cabin space or increase the drag (and therefore fuel consumption) if installed externally.

Moreover a *reduction of fuel consumption* is *not contingent upon the sole engine* and although the engine plays a fundamental role for consumption reduction it *is also necessary to streamline the aircraft as much as possible.* This streamlining effort is most rewarding for long distance trips and a certain increase of the empty weight is acceptable if it leads to a drag reduction. It is generally thought that a retractable landing gear, though heavier than a fixed landing gear, is a better alternative if the distance to cover is over 200/300 km.

Increasing the distances covered, yes, but the pay-load must remain positive. This capability is defined by the pay-load/range curve which is all the better as the empty weight is reduced, the take-off weight high, the specific fuel consumption good with a few possible limitations of the take-off weight in order to take into account single-engine performance in certain conditions of flight.

2.2 - **THE ENVIRONMENT** is very particular

Aircraft fly constantly *over water.*

In such conditions, *flight safety* calls for *twin-engine configuration* provided the helicopter is capable of single-engine flight in suitable conditions and provided the rest of the aircraft — blades, tail and main rotors, transmission systems — *is very reliable.*

Anyway, to ward off any problem, off-shore aircraft must be fitted with an *emergency floatation gear* which must be the lightest possible and must not affect the drag and flight qualities of the aircraft. Incidentally, the need for a large fuel tank can help finding the necessary floatation volumes provided they are well distributed in the aircraft.

2.3 - **THE USE OF THE AIRCRAFT ON NARROW PLATFORMS** swept by strong winds

- imposes the search for the *minimum aircraft size* compatible with the missions.
- offers a good justification for a *tricycle landing gear* with smaller overall dimensions on ground and a better maneuverability on narrow areas,
- favors aircraft with a *main rotor of small diameter* fitted with blades having limited flapping motion when the aircraft is on ground with its rotor stopped, as well as aircraft with *well protected tail rotors* preventing any unwanted contact with possible obstacles or ground personnel.

Lastly, the salty environment imposes *particularly effective protective treatments. The use of composite materials* for the manufacture of the major assemblies, such as blades, hub and structure elements, can make a very positive contribution in this respect.

2.4 - **THE COMFORT** offered by off-shore helicopters is becoming all the more important as the distances covered are long and the personnel travelling in the helicopter is usually sorely tired after a long stay on a platform.

Comfort means low vibration and noise levels in the cabin, soft seats, a pleasant cabin layout and a sufficient visibility to avoid claustrophobia effects.

2.5 - Off-shore aircraft *EQUIPMENT* also must be adapted to missions.

Besides conventional equipment items necessary for flying, an automatic pilot is highly desirable to relieve the pilot and becomes indispensable for IFR flights. It must be sufficiently redundant even to cope with any simple failure, which entails the availability of a duplex automatic pilot.

Radio-communication and radio-navigation systems must be reliable and even redundant to a certain extent.

Lastly the aircraft must be capable of carrying the necessary equipment for survival in case of ditching — dinghy, survival kit — with a maximum simplicity of use.

Another particular piece of equipment, the rotor de-icing system can turn out to be indispensable in certain regions since it makes flight in icing conditions possible without restrictions.

Although there may be a need for it only during a small fraction of the total flying time, it may yet be very useful to have the possibility of fitting it quickly on a helicopter in case of need or at the time of the year when this need comes to light, thus making sure the mission will be carried out whatever the weather.

2.6 - **MAINTENANCE OPERATIONS** must be reduced to a minimum because working conditions on platforms are already severe. Pre-flight and post-flight maintenance should necessitate no special work but a rapid visual inspection. Work on the aircraft, when necessary, must be easy to perform with only a few man/hours. Lastly blade folding must be possible without any particular difficulty.

3 - ADAPTATION OF THE 365 N TO THESE OFF-SHORE MISSIONS

Although derived from the 365 C (fig. 2), the 365 N (fig. 3), features a certain number of improvements mainly intended to meet the off-shore operation requirements.

3.1 - **IMPROVED PERFORMANCE** and especially improved pay-load distance covered thanks to the following modifications.

3.1.1 - New main blades

These new blades use the new OA2 profiles developed in cooperation with ONERA and characterized by a very advantageous Cz max, drag divergence Mach number and lift to drag ratio.

This new blade, whose main features appear on fig. 4, has a wider chord (385 mm instead of 350 mm for 365 C blades) an increased twist (10^{o} instead of 8^{o} for 365 C blades) and a thickness ratio varying from 12% at the blade root to 7% at the tip (instead of a constant thickness of 12% on the 365 C). For the same power, these new blades increase the 365 N take-off weight by about 100 kg, (the rotor figure of merit reach .75 - fig. 5). They reduce the energy consumed in cruise with all other things being equal, and make higher total weights and speeds possible. This allows the 365 N to utilize as fully as possible its increased installed power to offer an increased total weight : 3.6 tons and even 3.8 tons instead of 3.4 tons for the 365 C.

3.1.2 - 1C Arriel engines

These developed Arriel engines give a noticeable increased power with :

– a max. contingency power of	522 kW	(710 hp)
– an intermediate contingency power of	512 kW	(696 hp)
– a take-off power	494 kW	(669 hp)
– a max. continuous power	437 kW	(594 hp)

The corresponding values for the 1A Arriel being :

498 kW – 480 kW – 470 kW - 432 kW

– Moreover, the use of dynamic air-intakes reduces power losses due to engine installation especially in climb or at high speed, which helps improving noticeably simple-engine and cruise performance. Figure 6 states the characteristics of the various engine versions of the 365 C, 365 N and the 366 G version (Coast guard).

3.1.3 - Up-graded main gear box

The power capacity of the main gear box has been increased to 800 kW on the main rotor and 570 kW for each engine input (instead of 700 and 523 kW for the 365 C), thanks to tooth and bearing reinforcements especially at the epicycloidal stage.

The strength of this box has been tested during 100 hours at an output power of 1120 kW and a power of 741 kW at each input. Moreover, tooth corrections have been made simultaneously with a view to obtaining a noise reduction.

3.1.4 - The more streamlined *FUSELAGE* with its retractable landing gear and footsteps, also makes it possible to reduce cruise fuel consumption while increasing the speed. Thanks to an additional fairing on the rotor shaft (fig. 7), specially designed for a more regular airflow behind the shaft and a reduced drag, it has been possible to obtain a total drag of about 1 m2 (11 sp.ft.) for the C x S, which is an excellent result for an aircraft in this category.

This is why the 365 N is the fastest helicopter in its category with a VNE of 175 kt (324 km/h) and a fast cruising speed of 155 kt (287 km/h) at sea level.

The resulting *fuel consumption* is noticeably lower than that of the 365 C. While it varies with the total weight and altitude, it averages 1 kg/km which represents a 14% cut as compared with the 365 C consumption in clean configuration and over 20% if comparing aircraft fitted with the emergency floatation gear (fig. 8).

3.1.5 - Large capacity *FUEL TANKS* (1100 l), confer upon the 365 N the desired long range capability. These tanks are located below the cabin floor and have therefore no effect on the aircraft's drag.

The range without reserve is about 900 km and can be increased to 1030 km by adding an optional auxiliary tank located within the baggage compartment.

3.1.6 - The 365 N *EMPTY WEIGHT* has been watched closely during the design phase.

In spite of weight increasing due to improvements such as the retractable tricycle landing gear, the larger tank capacity, the integrated nose radome the new main rotor, the up-graded transmission, the two extra doors and the structure reinforcements needed for the total weight increase, the empty weight has remained close to that of the 365 C. With its certification total weight which should reach 3800 kg, the 365 N will offer a particularly attractive empty weight to total weight ratio of .5.

Taking into account the emergency floatation gear, the 365 N further increases its lead on the 365 C thanks to its very light integrated floatation gear that does not generate any drag.

The following table (fig. 10) shows a comparison between the 365 C and the 365 N in a standard off-shore version :

These figures differing from already published figures result from the latest in flight measurements. They cannot be considered guaranted values for the time being.

As this table shows, the performance of the 365 N is substantially higher than that of the 365 C in its present version. Incidentally, the existing 365 C helicopters can be upgraded by resorting to evolutions characteristic of the 365 N.

3.2 - **THE 365 N ADAPTATION TO OFF-SHORE ENVIRONMENT** capitalizes on the relevant characteristics of the 365.C.

3.2.1 - The *SMALL SIZE OF THE AIRCRAFT* makes it the smallest 14 seater on the market.

It is attributable to the limited main rotor diameter and the general configuration of the aircraft.

This leads to a lighter empty weight and, makes it possible to maintain the blade tips sufficiently high above ground to ensure the safety of maintenance personnel and passengers.

3.2.2 - The composite *MAIN ROTOR* blades and hub does not only contribute towards the empty weight reduction and the aircraft reliability but also is very well adapted to operations in strong wind conditions. Thanks to its flapping stops it is possible to start and stop the rotor by winds up to 50 knots. Moreover, it is insensitive to corrosion (fig. 11).

3.2.3 - The *FENESTRON OR SHROUDED TAIL ROTOR* facilitates maneuvering and landing on narrow platforms. It also improves the safety of ground personnel and of the aircraft in flight since the blades of the Fenestron are practically insensitive to speed as regards stressing, the tail rotor thrust being practically nil in cruise.

But there are other characteristics typical of the 365 N and contributing to its good suitability to off-shore environment.

3.2.4 - The *EMERGENCY FLOATATION GEAR* does not induce any additional drag when folded since it is particularly well integrated into the general shape of the aircraft. Benefiting from the large capacity of the fuel tanks located in the lower parts of the aircraft, the floatation gear takes up a limited volume and it has been possible to cut its weight down to a relatively low figure : 69 kg only for an aircraft total weight of 3800 kf (fig. 12).

3.2.5 - The *RETRACTABLE TRICYCLE LANDING GEAR* of a very simple design gives the aircraft a high degree of maneuverability on narrow sites and facilitates precision landings. Its characteristics, when added to those of the starflex rotor head eliminate any possible ground resonance. Its energy absorption capability permits proceeding to quick landings with no particular precautions which is a very valuable asset for bad-weather landings on narrow platforms (fig. 13).

3.2.6 - The *VIBRATION LEVEL* has been further improved as compared to the vibration level of the 365 C thanks to a better dynamic adaptation of main rotor blades and a suspension retaining the same principle as that of the 365 C, but using flexible fiber-glass elements, which increases efficiency and reduces the weight (fig. 14).

3.2.7 - *CABIN SPACE AND ACCESSIBILITY*

These have been improved by the removal of the 365 C control tunnel and by the addition of two doors for the pilot and co-pilot, whose seats have been moved further apart to make more space for the central console and improve outside visibility for the crew (fig. 15).

The baggage hold, which communicates with the cabin, has been appreciably enlarged.

3.2.8 - *EQUIPMENT*

In addition to the usual flight instruments, engine and transmission monitoring systems and essential radio and navigation items, the 365 N has complete redundancy in its hydraulic system (dual servo-controls in tandem on all axes except yaw, dual generation system) and in the automatic pilot (Duplex SFIM 155 system). It also has dual electrical power generation.

The aircraft can be fitted not only with emergency floatation gear but also with the survival equipment in case of ditching (dinghy, survival kit, flares, etc ..).

Lastly it can be equipped for flight in icing conditions without restriction, as is already the case for the SA 330 PUMA.

The blades can be fitted with a leading edge heating mat working on a cyclic power supply from a 10 kVA alternator driven by the main gear box.

In addition to the icing indicator, it is the only necessary equipment in icing conditions. Tests carried out in a wind tunnel reproducing icing conditions have shown that de-icing of the Fenestron is not necessary. In forward flight, blades practically do not collect any ice thanks to the rotor protection and the almost nil flow in the air duct.

In addition to that, the Fenestron is heated by the turbine exhaust in forward flight.

3.2.9 - *MAINTENANCE OPERATIONS* are made as simple as possible on the 365 N.

Routine maintenance operations before and after flight do not need opening any cowling. A quick glance is sufficient to check engine, MGB, or hydraulic system oil levels or to verify that the starflex hub, its spherical bearings and its viscoelastic dampers are in good condition while the Fenestron is at the right height for a purely visual check.

Periodic maintenance operations are also facilitated by the reduced number of components.

The starflex rotor is very simple. Its few components can be replaced without any special tool and its fail safe design allows returning to the mainland even if a defect is noticed while the aircraft is on an off-shore platform.

There is no intermediate gear box and the tail gear box/Fenestron assembly can be replaced easily thanks to its small size and weight.

The replacement of a blade, an engine or the MGB is also a relatively simple operation with no special toolings.

3.2.10 - *The COST-EFFECTIVENESS OF THE 365 N* will be a considerable improvement if compared with that of the 365 C.

This is first due to the performance, as indicated on the table (fig. 10) especially its valuable pay-load and its low fuel consumption, but also to the improvements on the aircraft itself as regards TBO, service life, maintenance.

It is premature yet to compute accurately the DOC per carried kg in relation to the distance but the result of the calculation should reflect the substantial improvement of the 365 N as compared with the 365 C.

4 - CONCLUSION

The Dauphin 2 - 365 C, which has been the first aircraft of that class on the market is a valuable machine for off-shore missions.

However, experience gained with the 365 C, utilisation of more advanced technical solutions,increase of power installed and a better design optimisation, made possible the definition of the Dauphin 2 365 N, which represents a significant improvement.

It is interesting to point out that it is possible to improve the existing 365 C by using partially the new solutions of the 365 N.

Good adequacy of the 365 N to off-shore missions put it in a good position to win the US Coat Guards competition, as everyone knows.

It is clear that this new Dauphin 2 should be attractive to many customers and not only for off-shore missions.

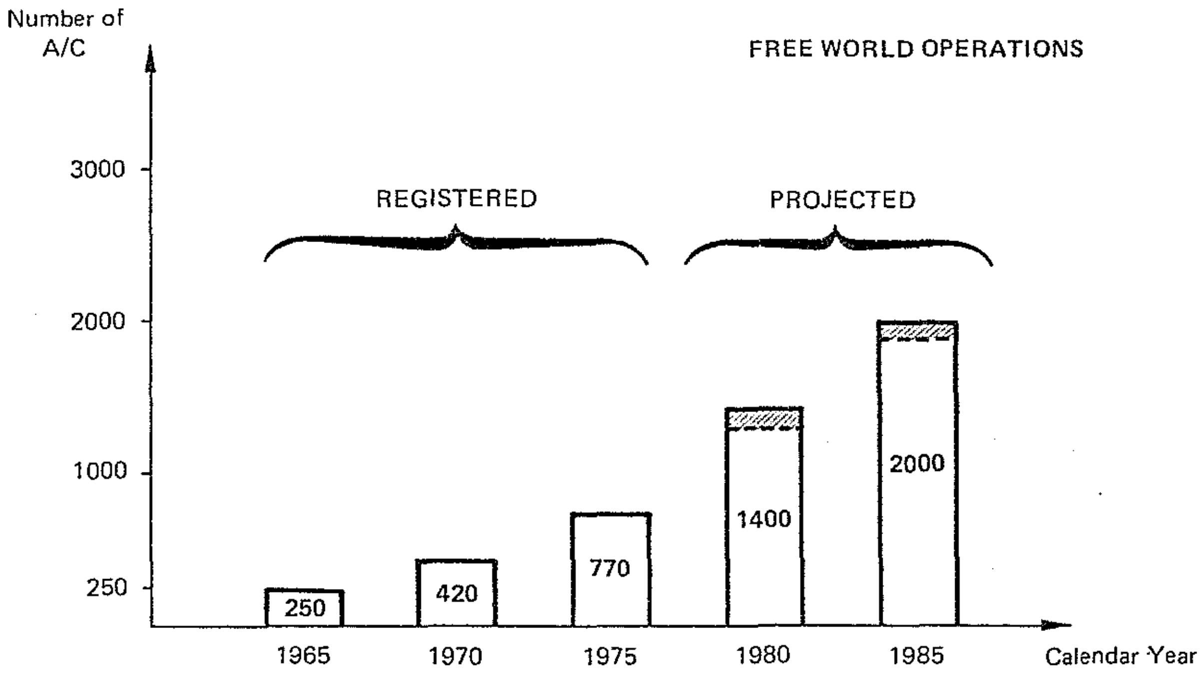


FIG 1 — HISTORICAL TREND IN HELICOPTER OFF-SHORE APPLICATION

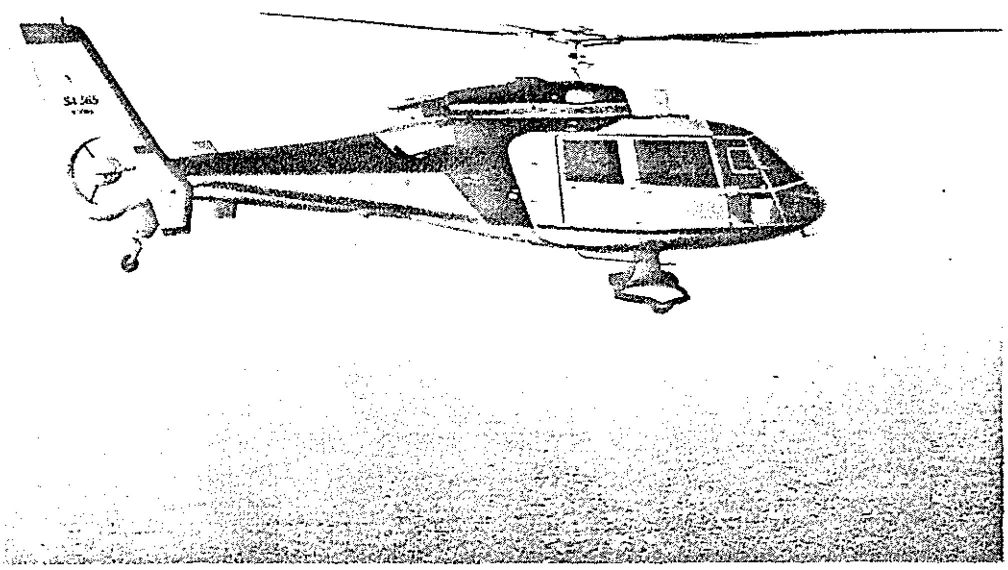


FIG 2 — DAUPHIN SA 365 C

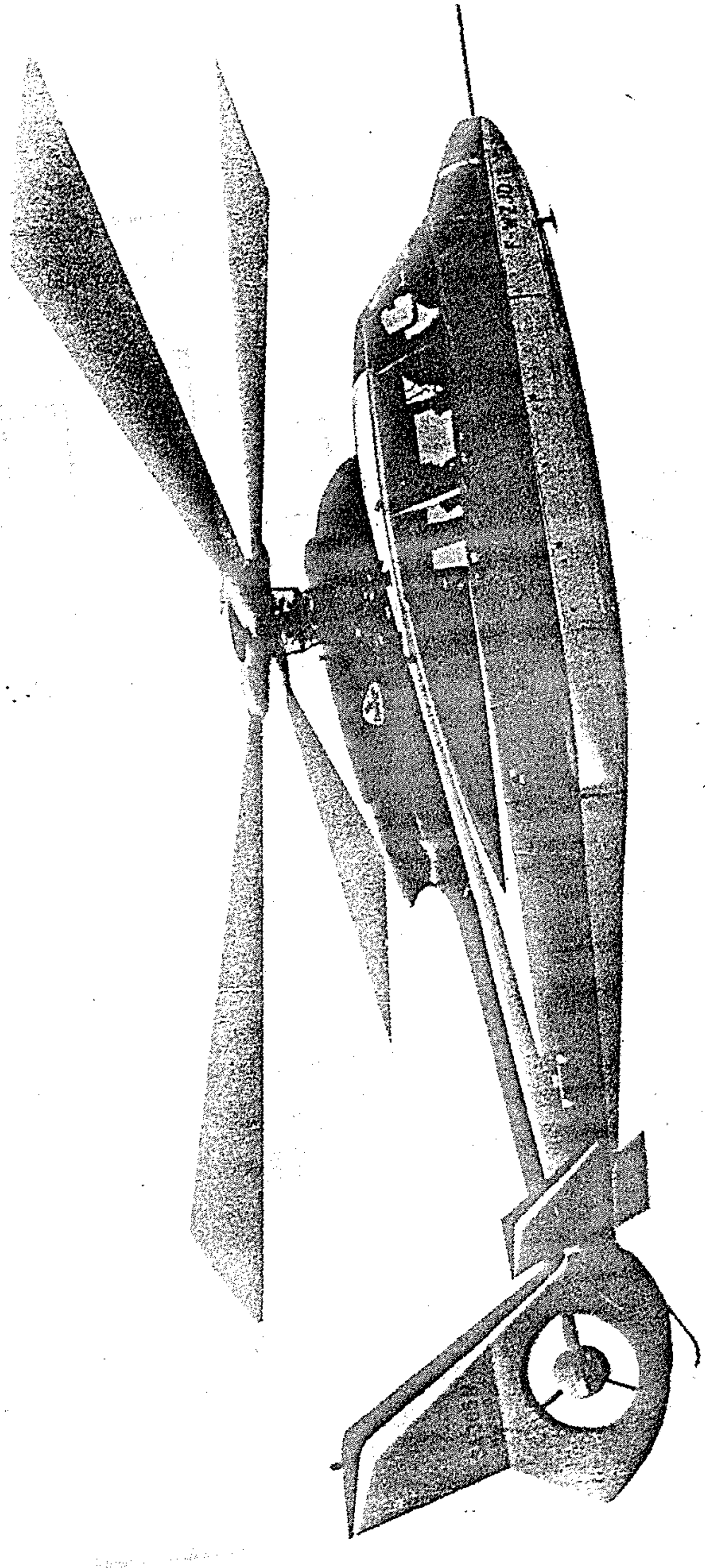


FIG. 3 – DAUPHIN AS - 365 N

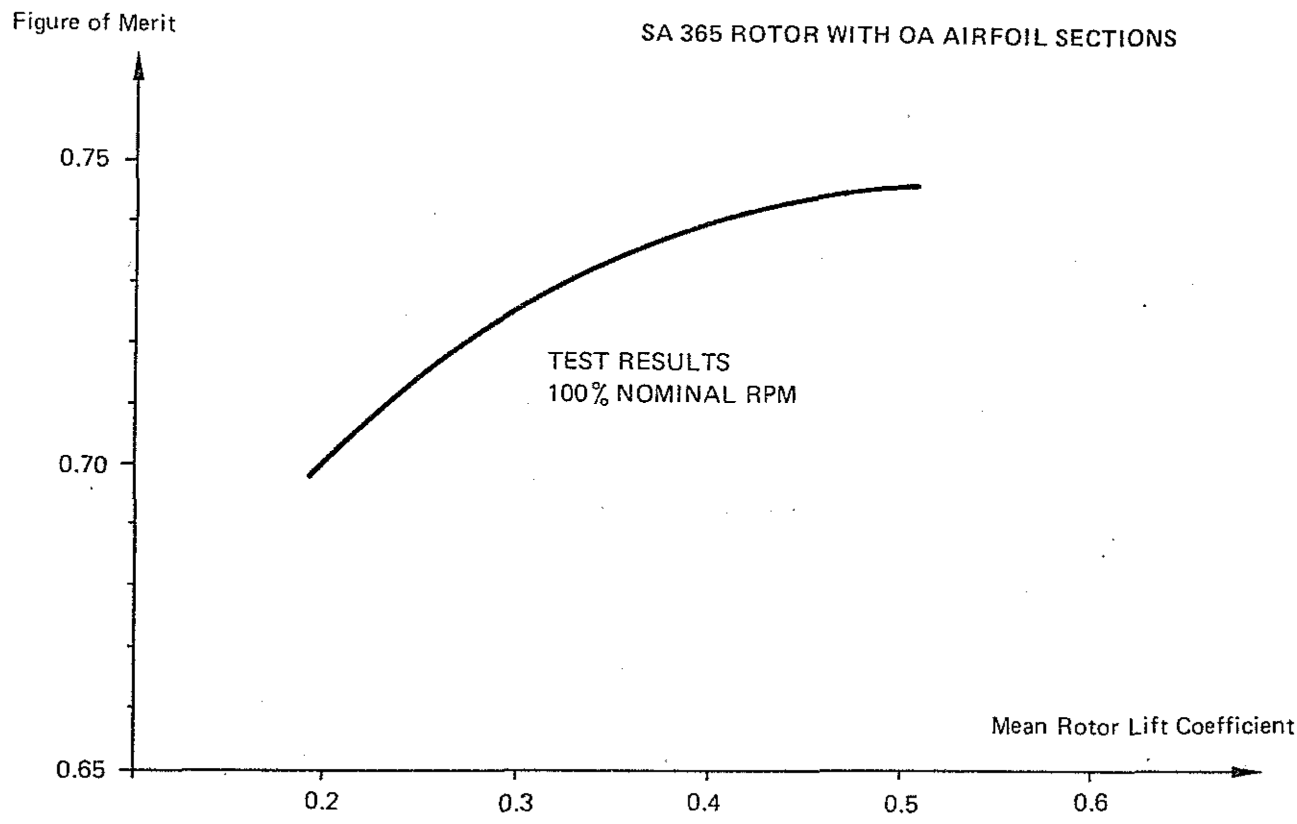


FIG 5 – ISOLATED ROTOR FIGURE OF MERIT

ENGINE POWER RATING		ENGINE					
		ARRIEL 1 A		ARRIEL 1 C		LTS 101 - 750 CG	
MCP	2,5 mn	498 kW	678 ch	522 kW	710 ch	548 kW	746 ch
ICP	30 mn	480 kW	653 ch	512 kW	696 ch	520 kW	707 ch
MTOP	5 mn	470 kW	639 ch	492 kW	669 ch	502 kW	687 ch
MCP	continuous	432 kW	568 ch	437 kW	594 ch	477 kW	653 ch

FIG. 6 – ENGINE POWER COMPARISON

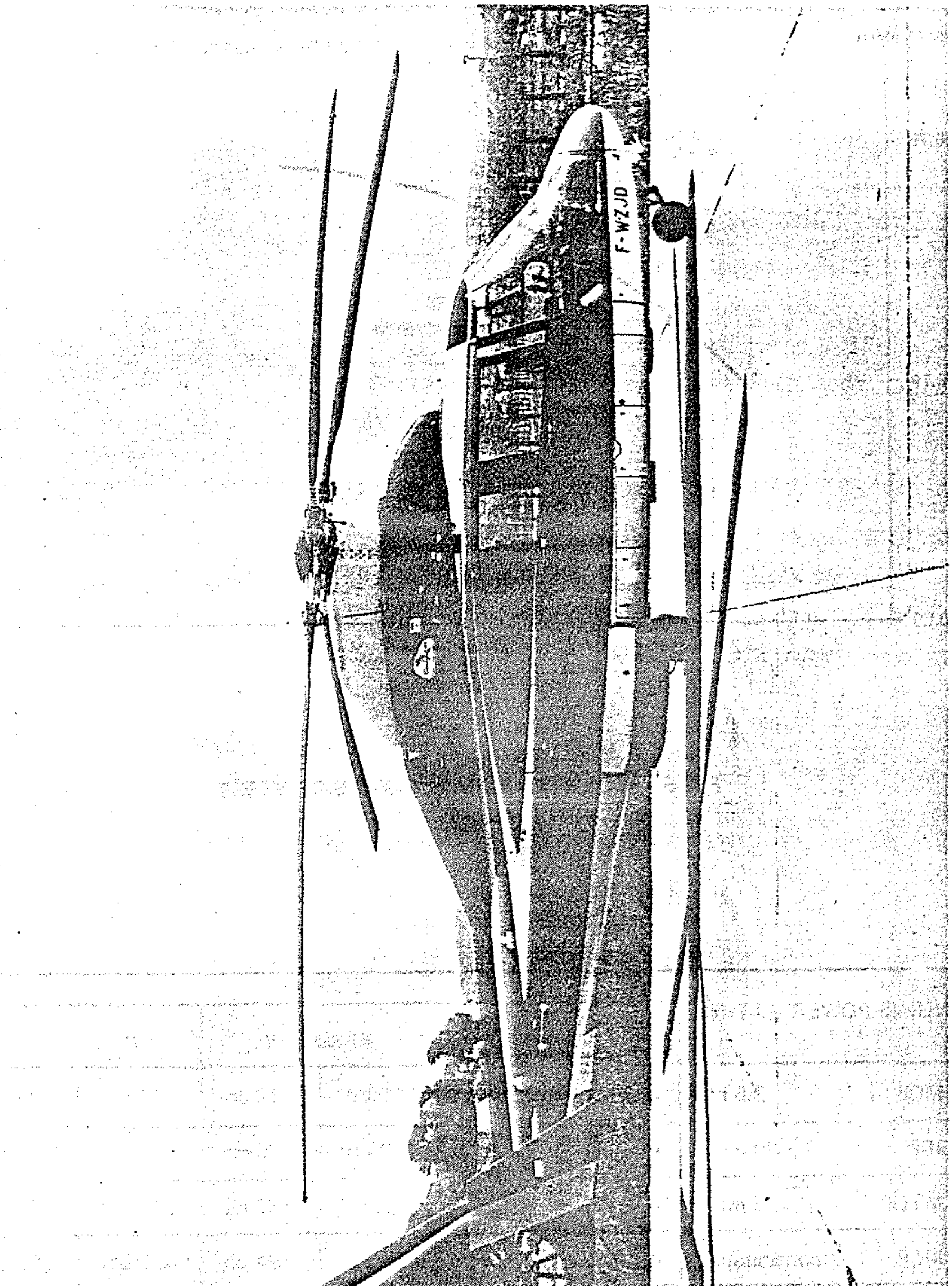


FIG. 7 – SA 365 N

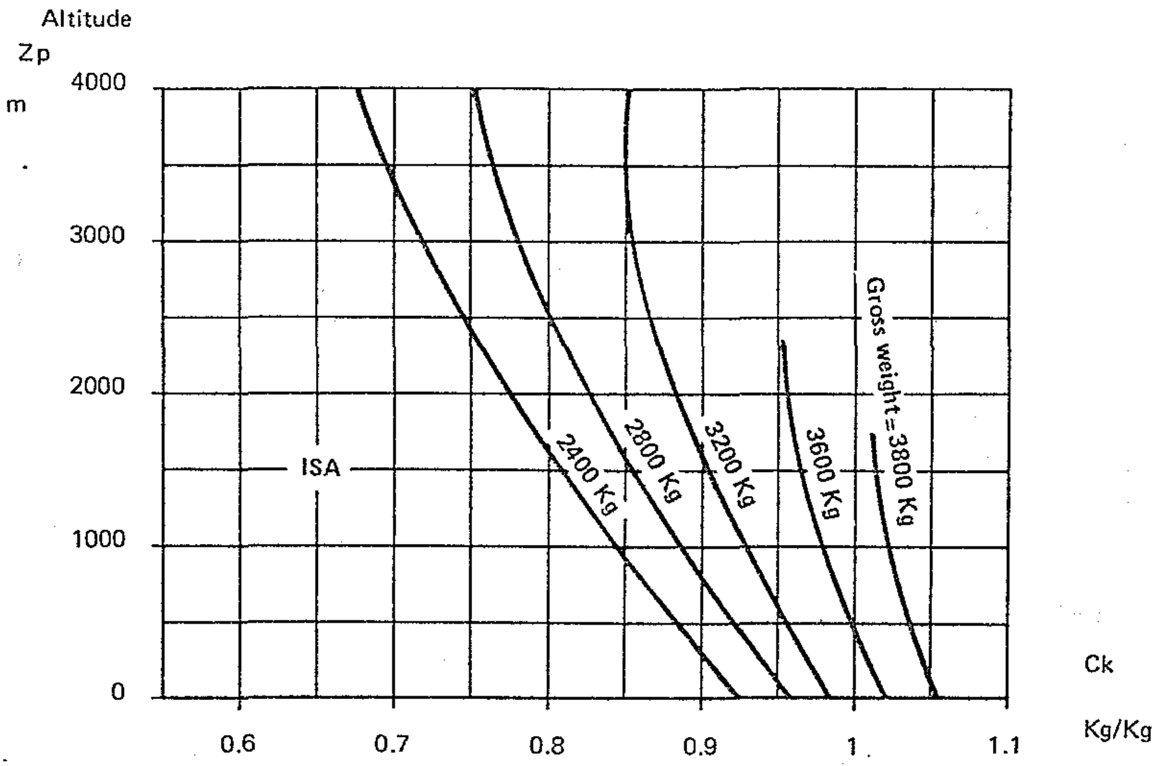


FIG 8 — FUEL CONSUMPTION AT ECONOMICAL CRUISE SPEED
WITH 2 ENGINES OPERATING

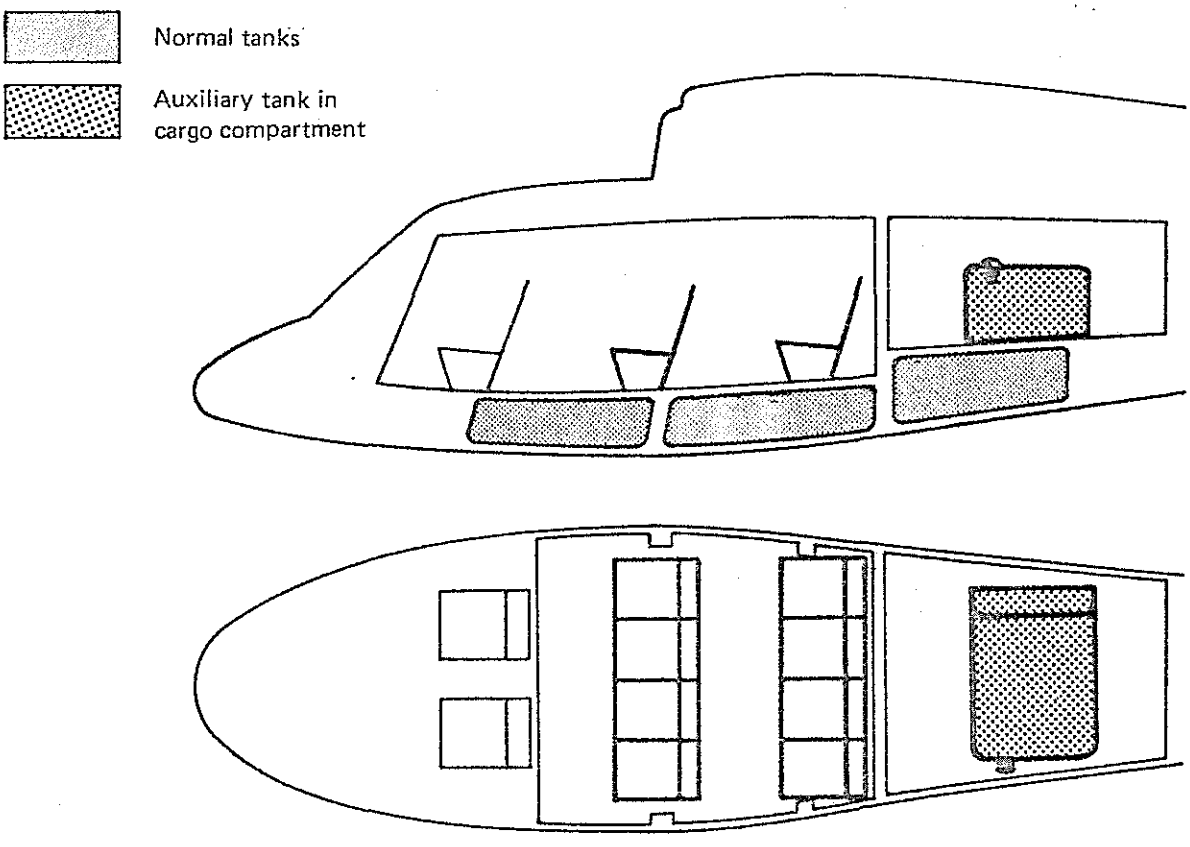


FIG 9 — 365 N - FUEL TANK LAYOUT

	365 C	365 N
Basic empty weight	1 860 kg	1 900 kg
Emergency floatation gear	105 kg	69 kg
Fuel jettison system Radar installation Dinghy, survival equipment Radio-com equipment Radio-navigation equipment — A.P Auxiliary tank (for 365 C only)	167 kg	127 kg
Empty weight equiped	2 132 kg	2 096 kg
Total weight	3 400 kg	3 800 kg
Pay-load	1 268 kg	1 704 kg
Category A take-off (FAA)	3 370 kg	3 800 kg
Fuel consumption, kg/km	1,20	1
Maximum range with auxiliary tank	570 km	1 030 km
Capacity	8 people including crew over 540 km	10 people including crew over 900 km

FIG 10

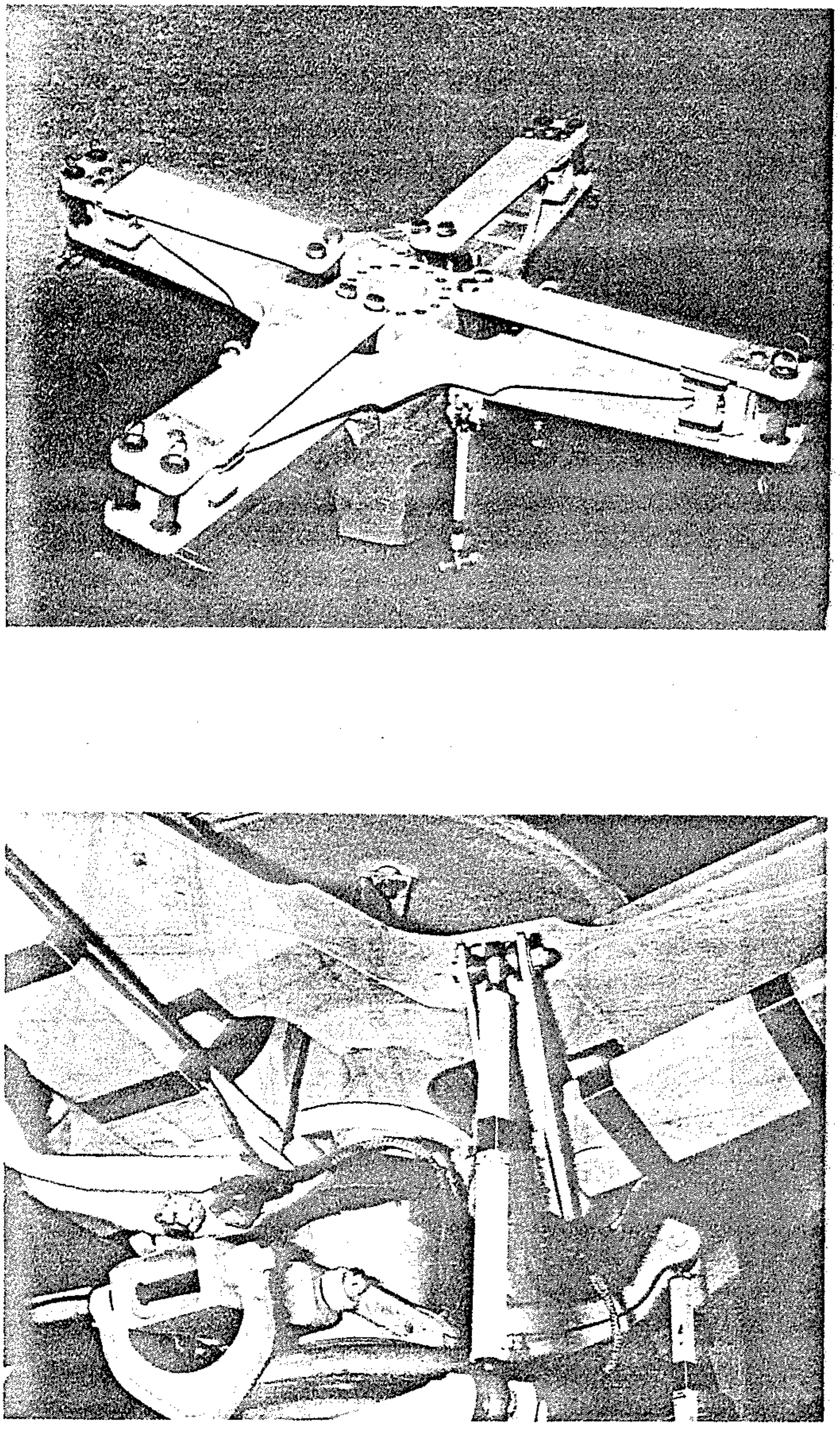


FIG. 11 – SA 365 C - STARFLEX ROTOR HEAD WITH DROOP RESTRAINERS

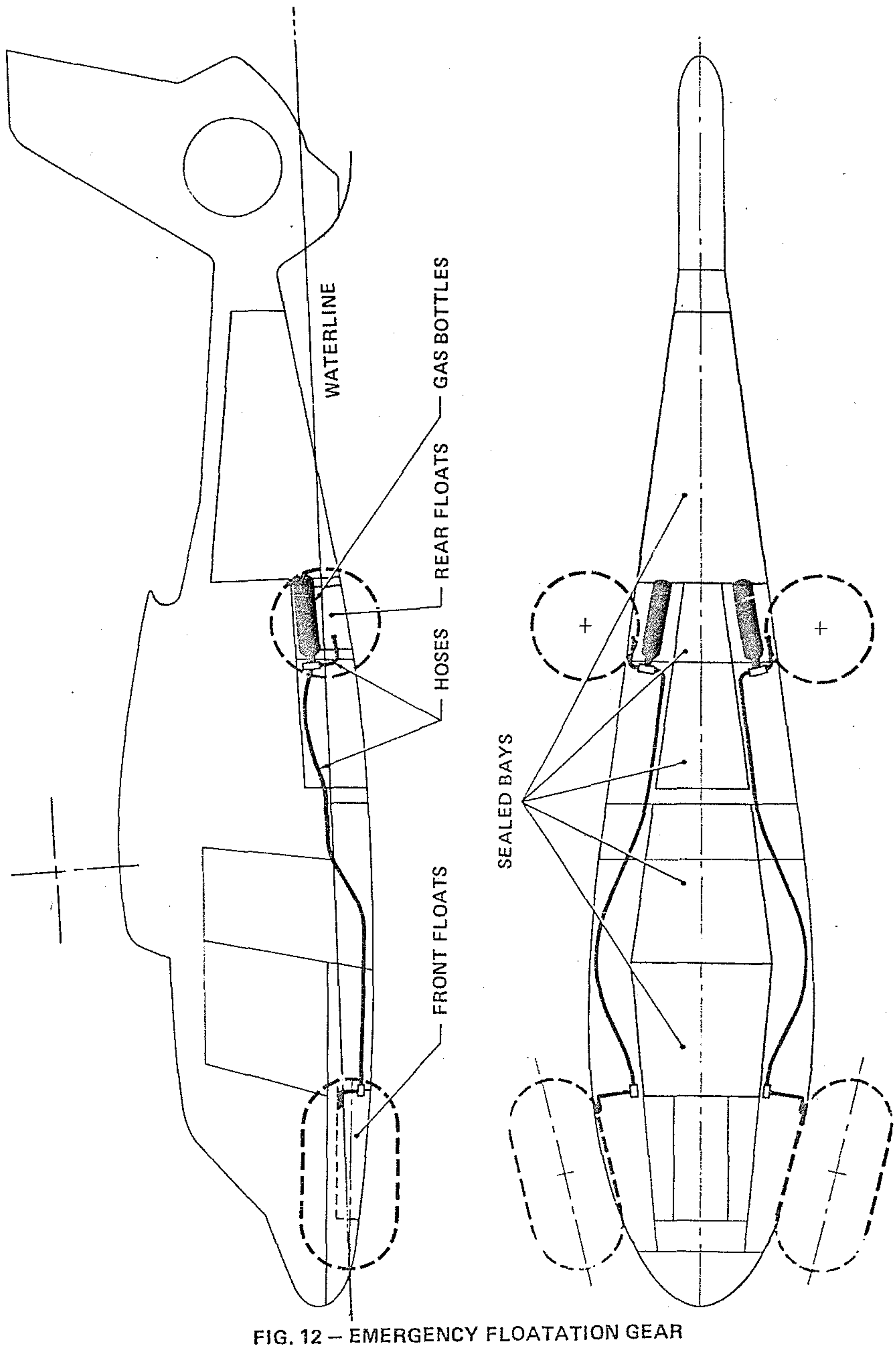


FIG. 12 – EMERGENCY FLOATATION GEAR

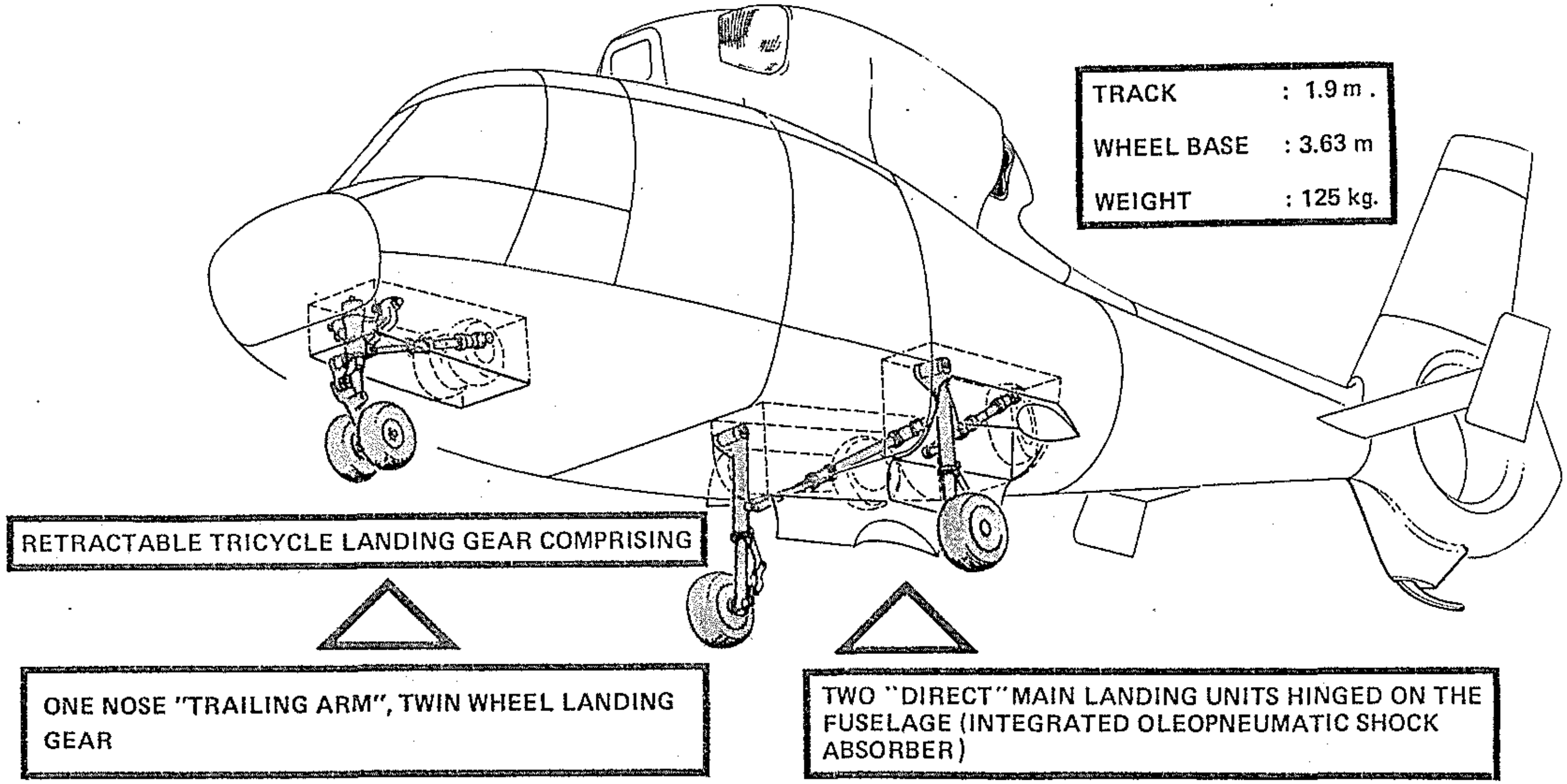


FIG. 13 – DAUPHIN 365 LANDING GEAR

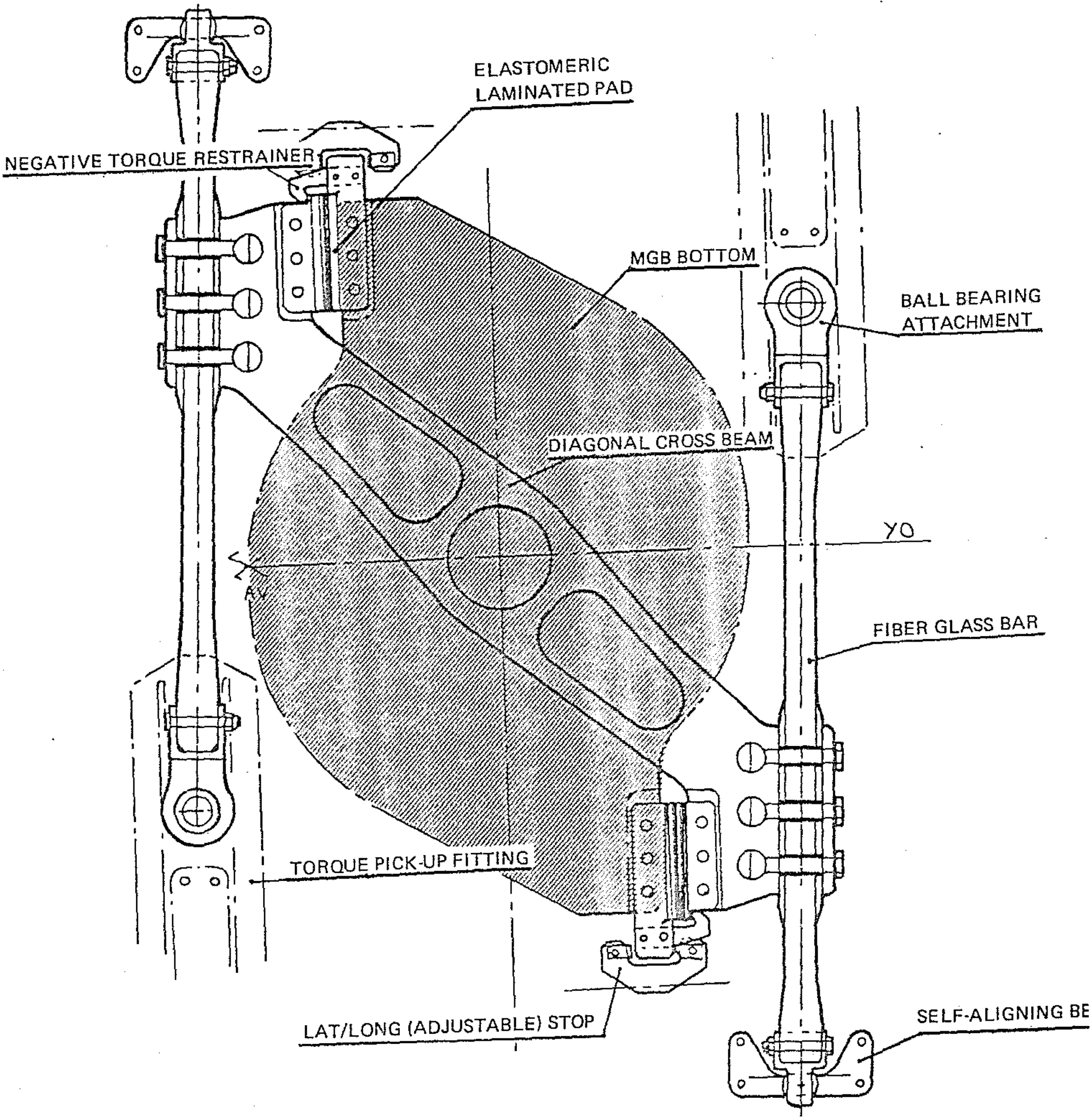
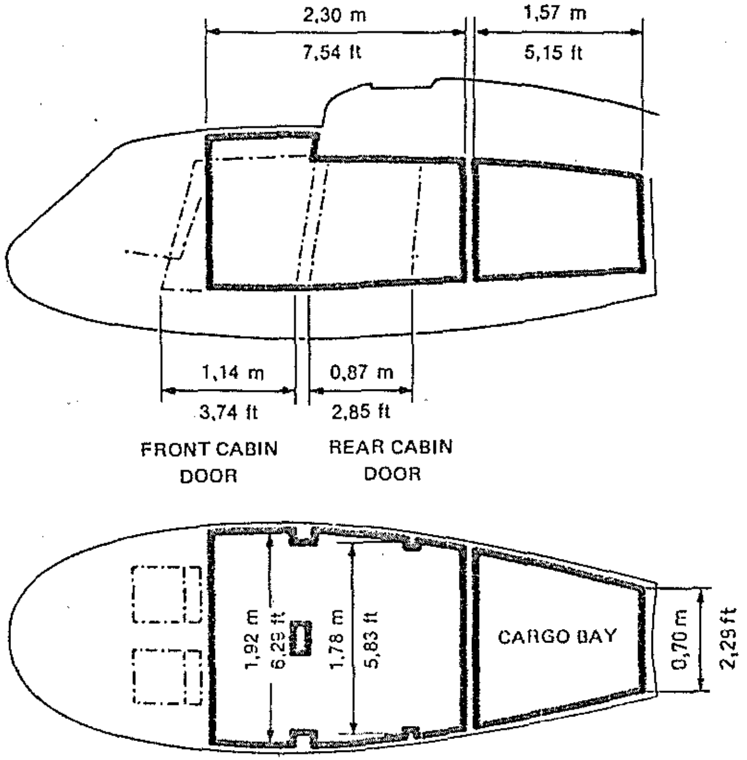


FIG. 14 – AS 365 N MGB MOUNTING

FIG. 15 — CABIN SPACE COMPARISON BETWEEN SA - 365 C & AS - 365 N

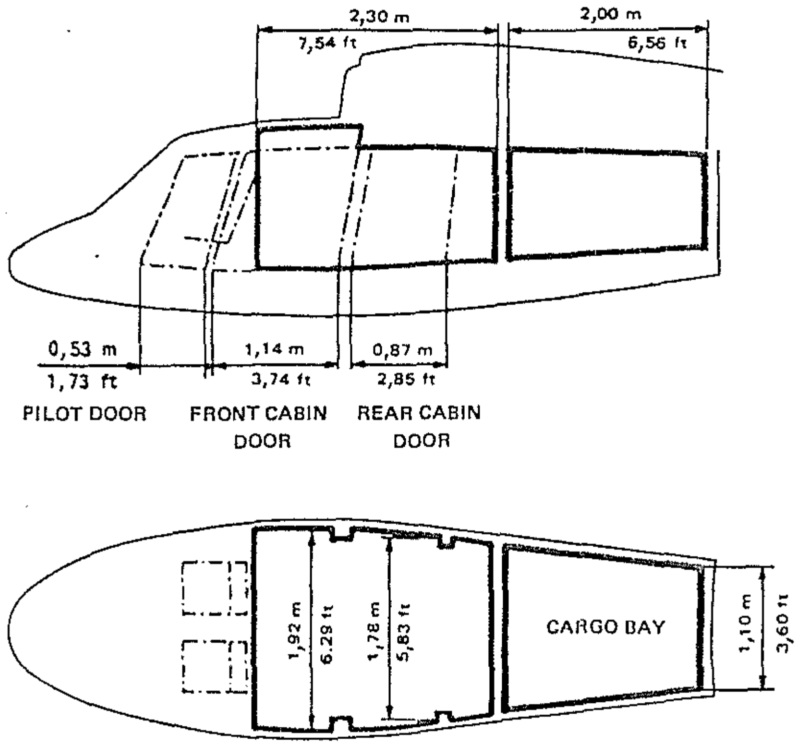
365 C



CABIN	
Area	4,20 m² 45,20 sq.ft.
Volume	5,00 m³ 176,57 cu.ft.

CARGO BAY	
Area	1,15 m² 12,37 sq.ft.
Volume	1,00 m³ 35,31 cu.ft.

365 N



CABIN	
Area	4,20 m² 45,20 sq.ft.
Volume	5,00 m³ 176,57 cu.ft.

CARGO BAY	
Area	2,60 m² 27,97 sq.ft
Volume	2,20 m³ 77,68 cù.ft

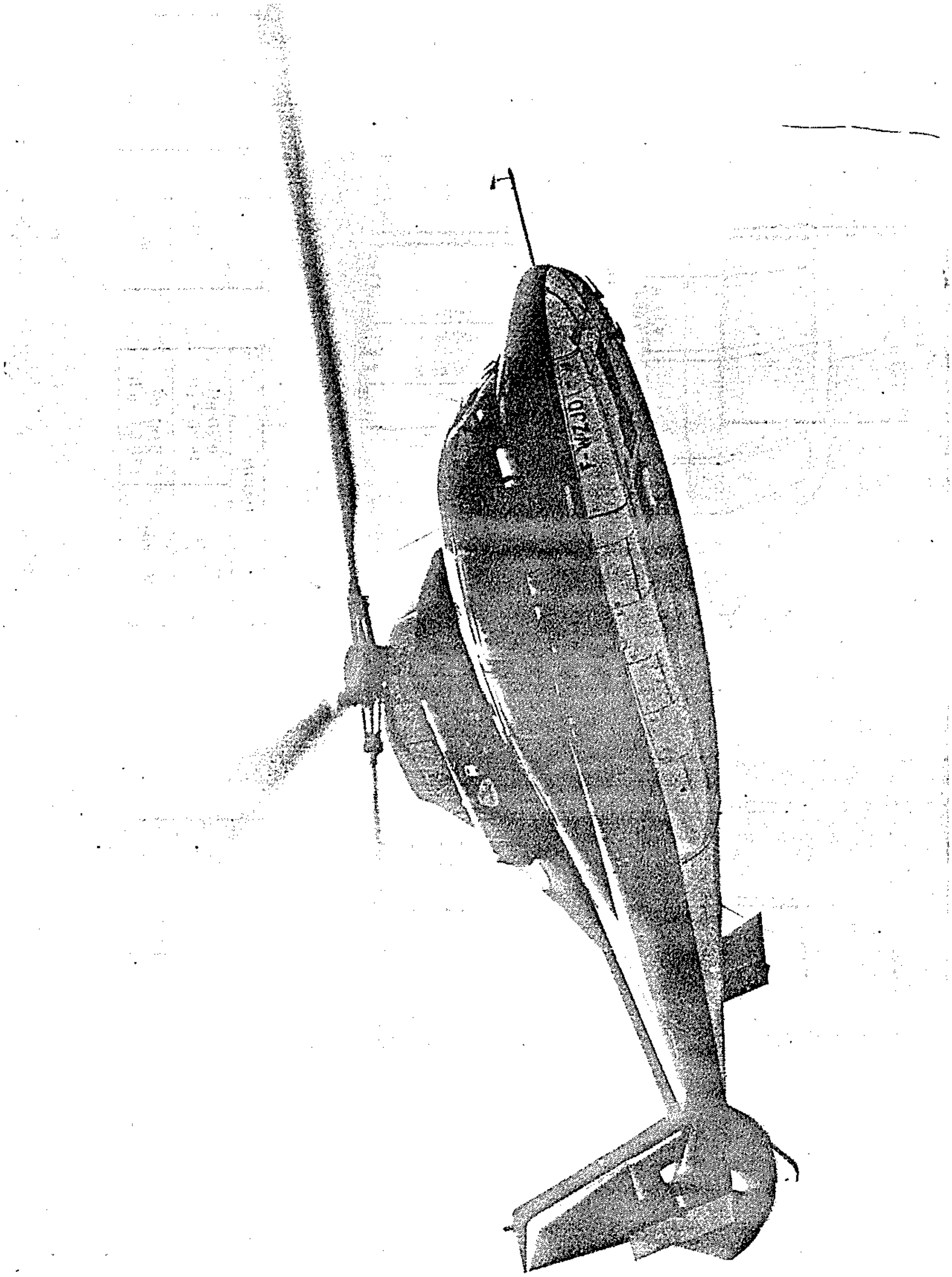


FIG 16 – SA 365 N