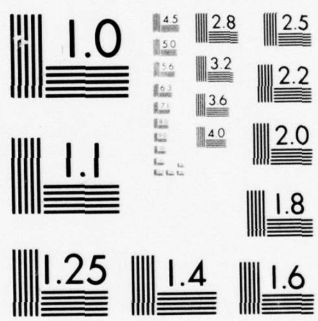
AD-A039 075 FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OHIO F/G 20/4
THE DOLPHIN PRINCIPLE, ITS TECHNICAL CONVERSION AND APPLICATION--ETC(U)
NOV 76 U QUECK
UNCLASSIFIED FTD-ID(RS)I-1330-76 NL

1 OF 1
AD
A039075

END
DATE
FILMED
5-77




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

FTD-ID(RS)I-1330-76

AD-A039075

# FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

THE DOLPHIN PRINCIPLE, ITS TECHNICAL CONVERSION AND APPLICATION IN AERONAUTICS

by

U. Queck

FOREIGN TECHNOLOGY DIVISION

# EDITED TRANSLATION

(14) FTD-ID(RS)I-1330-76 (11) 8 November 1976 (12) 34p.

FTD-76-C-001170

(6) THE DOLPHIN PRINCIPLE, ITS TECHNICAL CONVERSION AND APPLICATION IN AERONAUTICS

By: (10) U. Queck

English pages: 31

Source: (21) Trans. of Technischoknomische Information der Zivilen Luftfahrt, Vol 11, Nr 2, 1975, PP. 83-101

Country of origin: (East Germany) v11 n2 p83-101 1975.

Translated by: SCITRAN
F33657-76-D-0390

Requester: FTD/PDXS

Approved for public release; distribution unlimited.

| | |
|---|---|
| THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT. STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION. | PREPARED BY: TRANSLATION DIVISION FOREIGN TECHNOLOGY DIVISION WP-AFB, OHIO. |



141 600

LB

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>FTD-ID(RS)I-1330-76 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>THE DOLPHIN PRINCIPLE, ITS TECHNICAL CONVERSION AND APPLICATION IN AERONAUTICS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Translation |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>U. Queck | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Foreign Technology Division<br>Air Force Systems Command<br>U. S. Air Force | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS | | 12. REPORT DATE<br>1975 |
| | | 13. NUMBER OF PAGES<br>31 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

01

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

FTD-ID(RS)I-1330-76

# FOREIGN TECHNOLOGY DIVISION

THE DOLPHIN PRINCIPLE, ITS TECHNICAL CONVERSION AND APPLICATION IN AERONAUTICS

by

U. Queck

# EDITED TRANSLATION

FTD-ID(RS)I-1330-76 8 November 1976

FTD-76-C-001170

THE DOLPHIN PRINCIPLE, ITS TECHNICAL CONVERSION AND APPLICATION IN AERONAUTICS

By: U. Queck

English pages: 31

Source: Technischoknomische Information der Zivilen Luftfahrt, Vol 11, Nr 2, 1975, PP. 83-101

Country of origin: East Germany
Translated by: SCITRAN
F33657-76-D-0390
Requester: FTD/PDXS
Approved for public release; distribution unlimited.

| | |
|---|---|
| THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT. STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION. | PREPARED BY: TRANSLATION DIVISION FOREIGN TECHNOLOGY DIVISION WP-AFB, OHIO. |

Aeronautics, wave propeller, theoretical foundation

Air travel in undulating flow

# THE DOLPHIN PRINCIPLE, ITS TECHNICAL CONVERSION AND APPLICATION IN AERONAUTICS

Ulrich Queck

A contribution to the discussion about a new hypothesis

## 0. Introduction

In a struggle for existence lasting millions of years nature has evolved for each living creature the optimal method of movement in keeping with its environment. Scientific investigation of these nature-given methods, as well as their technical conversion and application for human society, are of great theoretical interest and practical value.

Studies concerning the movement of marine animals, fishes, birds and winged insects lead to the perception that for movement in the uniform medium water or air there are two opposing propulsion systems:
--- wave propulsion as well as
--- reaction propulsion.

Wave propulsion has found general application both in the water and the air since it is extraordinarily effective and economical. Reaction propulsion, on the other hand, is a decidedly special and likewise energy consuming propulsion which is employed by only a few animals such as cuttle-fish (in order to obscure the water with ink by reflection in flight), large dragon-fly larvae, cockles and siphonophora.

In present day aeronautics it is just the reverse. Whereas in motor-powered flight (airplane, helicopter, Zeppelin and nonrigid dirigible) the energy-wasteful reaction propulsion (propeller, jet propulsion and rocket) find application, wave propulsion is used solely in gliding for sport, in order to glide and soar (not, on the contrary, for "powered flight", analogous to the beating of the wings of birds).

The previous theory of flight mechanics, especially the aerodynamics of the airplane wing, is incomplete and is responsible for the fact that modern aviation is limited in a biased fashion to the energy-wasting recoil (reaction propulsion). It is determined in terms of a wing or body which, by means of propulsion, is forced through the medium air which offers quadratically increasing resistance with increasing velocity, and this resistance must be overcome by a propulsive output whose growth is measured in terms of the third power. We designate this action principle as "aeronautics in direct flow" /1/.

The communist economy of abundance, i.e., mass production on a grand scale, is based on rational utilization, but not however on uneconomical squandering of available raw materials. This holds in the same measure for fuel which is consumed in rapidly increasing amounts in aviation. It is therefore logical to use economical action principles whenever they present themselves.

Alone among all known means of transport, according to knowledge at hand, "Aeronautics in undulating flow," principally that involving the dolphin airship, is capable of accomplishing more effectively mass transport such as we have to expect in the future, or hauling specific heavy loads.

Must one not sit up and take notice when Boeing lays before the public a proposal to build a giant aircraft of conventional design, i.e., with reaction propulsion that is to consume 107 tons of kerosine per flight hour for its 12 jet turbines in order to transport a payload of 1000 tons: thus for a Berlin-Havana round trip roughly 2500 tons of kerosine! In fact, Dornier and other airplane builders predict 5000 to 10,000 ton giant aircraft of conventional kind. Some day there will certainly be aircraft with 10,000 ton payload, but only on the basis of a novel type of economical action principle. However, for airplanes which are not crash proof, and are handling large flight masses, airplanes which can also no longer make emergency landings except on concrete runways, the initiation of atomic drives must be strictly rejected, due to the environmental hazards involved. The conventional helicopter can lift economically at most up to approximately 50 tons payload. However, in the future, lifting equipment will be used for building and installation work from the air involving up to at least 1000 tons.

Thus the mass transport of the future requires an aircraft with a novel type of action principle which combines optimally the advantages of the airplane, the airship and the helicopter, and is at the same time crash proof, efficient and economical. The application of bionics can show us the way to such a new action principle through our transforming with technical correctness and applying the inherent principles of undulating flow to tomorrow's aeronautics, such as occur in natural wave drive. The naturally provided wave propulsion is represented most clearly by the manner in which dolphins swim; for this reason the new action principle will be called the "Dolphin Principle."

The following comments contain an investigation into this matter.

## 1. The Dolphin Principle

The eminent British zoologist James Gray established in 1936 that the propulsive power required for a rapidly swimming dolphin is much too large to be achieved by the existing muscles of the tail fins /6/. This power is calculated by multiplying the swimming velocity by the flow resistance to be overcome for the rigid body with a laminar boundary layer. With continuous power the dolphin swims more than 50 km/hr and indeed attains a peak velocity of over 80 km/hr.

What constitutes the "secret" of the rapidly swimming dolphin, the action principle of its propulsion?

The rapidly swimming dolphin does not shoot forward in a straight line, but moves through the water with the entire body whipping back and forth on a sinusoidal swimming path. In contrast to a propeller, neither turbulent flow nor a wake (so-called dead water) manifests itself behind the swimfins. From this one concludes that apparently the dolphin is able to utilize the total energy of propulsion essentially without resistance-enhancing cavitation on its tail.

But this is far from explaining why the dolphin can swim so fast. Apparently the classical law of flow does not hold for the dolphin. According to this law the flow resistance increases as the square of the velocity, and the required propulsive power, as the cube of the velocity. Why, however, does the dolphin's body whip back and forth while swimming: is it not paradoxical that he moves forward faster on a wave path than in the case of rectilinear forward movement? Experiments with models in the Kdt-Operations Commission for the Study of Air Travel (Team Reseach and Development Bureau for Air Travel) in the German Democratic Republic have confirmed, on the basis of many years of observations, the study of references and deliberations, what was at first hypothetically assumed as the "Dolphin Principle," and which became the stimulus for the inventive proposal toward the development of a "Dolphin Aircraft" /7/: not the tail fins alone form the propulsion; the entire dolphin is properly a uniform propulsion system. Here in an evolution lasting apparently 60 to 70 million years nature has created a genuine miracle in which all parts of the body cooperate optimally in the most complete fashion for propulsion.

As a rule the dolphin uses the tail fins first of all with one or two strokes as impact rudder to swim ashore. However, as soon as he has started to "travel" even a small amount, he at once begins to use his side fins in order to whip up or down with the front part of his body. Why? For what purpose?

In the case of a downward body stroke the fore-part of the body experiences oncoming flow from the front obliquely from below by means of the oblique flow $v_{rK}$ resulting from the forward and downward movement. The oblique flow on the underside of the fore-part of the body gives rise to suction on the upper side of the front of the body; i.e., the resultant flow force A, which essentially acts at right angles to the velocity $v_{rK}$ of the oncoming flow furnishes a forward thrust component $v_K$ (Figure 1). The oblique flow $v_{rK}$ which impacts on the forward underside of the body is dragged along forward by the forward moving body and forms a continuous counterclockwise eddy. Thus the downward stroke of the body sets up a "roller bearing" over which the body of the dolphin rolls away (Figure 2).

As a result of the downward body strokes, the rolling eddys, which rotate immediately, thus remaining stationary on the spot, staying behind the forward-gliding dolphin's body, are continuously fed edy energy from $RU_1$ through $RU_7$ (axis of rotation D) by means of the oblique oncoming flow from $v_{rK_2}$ through $v_{rK_7}$. Naturally the dolphin's skin must be especially elastic as a consequence of the flexing of its body, so that the "roll eddies" stand out clearly in the skin. Photographs show that the transverse folds "remain stationary on the spot" with the roll eddies and thus wander tailwards on the forward gliding dolphin's body.

In contrast to the boundary-layer eddies in direct flow, which arise unbidden and cause frictional resistance, the roll in undulating flow are deliberately generated by the stroke of the body and result at least in the reduction of resistance due to friction. Photos which show a section through the dolphin's skin clearly reveal that a roughness is present "against the grain." We find the same phenomenon in the case of fish (e.g. sharks), birds and insects. From this one concludes that the roll eddy, at least at the forward part of the body, not only "parallels" the swimming velocity, but in fact continues to deliver to the body a portion of the energy of rotation constantly supplied up to and including roll eddy $RU_7$; thus the dolphin can drive forward through "after thrusts."

The roll eddies which represent a directed, adjacent turbulence adapted to the body length by means of a definite stroke frequency must therefore be considered as multiples of small, incremental "propulsion units" on the dolphin's body.

After $RU_7$ no further rotational energy is fed to the roll eddies since the "center of rotation" for the upward stroke of the tail, which occurs simultaneously with the downward body stroke, lies here. Now in order not simply to waste uselessly -- by an inevitable surface friction on the tail -- the rotational energy invested in the roll eddies through the downward body stroke, and to avoid a very harmful body resistance through a change from laminar to turbulent flow, nature has evolved in the case of the dolphin a further optimal solution. The dolphin's body tapers off (Figure 3) and on the remaining narrow basal surface of the tail and the vertical lateral surface of the tail shaft, the roll eddies rapidly lose their energy of rotation and lag behind compared with the alternating "free eddies." Thus this lagging behind of the roll eddies which are still adjacent to the tail shaft brings about a "negative suction" which suffices to retain in place the "free eddies" and to direct them to the tail fins. At the same time that it strikes downward with its body, the dolphin strikes upward with the tail fins. This gives rise first of all to a stabilization, so to speak, the opposing force to the downward stroke of the body. But much more important is the fact that in this way on the upper side of the tail fins from forward obliquely from above an oncoming flow $v_{rS}$, analogous to the oblique flow $v_{rK}$, occurs on the bow of the body which, together with the negative suction on the tail section, generates a powerful propulsion $v_S$ (Fig. 1). G. V. Bogvinovich points out also that in connection with the "eel-like" swimming motion of fishes a suction force is formed "on the fore-part of the body of a fish and on the forward side of the tail fins." On the part of the body which narrows toward the tail fins there forms a negative suction force in the case of uninterrupted flow /9/ around the body.

If one considers the flow $v_{rK_1}$ which is still just "flowing past" from the front obliquely from below before the bow of the body, then this flow is grasped by the front and rolled clockwise by the suction arising from the downward body stroke; thus there forms along the dolphin's back an oppositely directed "roller bearing" (Figure 2). Opposite to the roll eddies on the underside of the body, which are steadily fed additional energy up to the rotation point $RU_7$ by means of the downward body stroke, the roll eddies of the upper side of the body receive through the suction only a single rotational impulse which is for that reason almost twice as powerful. While the upper side roll eddies initially have a strongly propulsive effect, their rotational energy nevertheless steadily decreases. It would be used up even before the end of the tail, but for the fact that through the upward tail stroke new energy is supplied; however the supply is only enough as is needed as compensation at the tail end in order to prevent a change from laminar to turbulent flow at the stern, resulting in harmful body resistance.

The downward body stroke follows the upward body stroke, in the course of which the side fins are used as "elevators." All events on the belly side now occur in "mirror image" fashion and conversely. Upward and downward body strokes alternate rhythmically with each other, so that the forward motion takes place along a sinusoidal swimming path.

Summarizing, it can be established that in the case of the normal high-speed swimming of dolphins there is no reflected wave or repulsion. It can also be assumed that there is as good as no downward eddy, since the stroke frequency of the body as well as the tail, together with the body length, are optimally coordinated with each other. Also there is thus no "wake" in the flow, i.e., no negative suction behind the tail fins to generate resistance.

The roll eddy, a deliberately generated, directed and adjacent turbulence, between which the body of the dolphin rolls as through a roller bearing, is called "undulating flow" or "wave flow."

As a rule, when stroke frequency and body length harmonize, the rotational energy of the roll eddies is consumed up to the end of the tail; thus the wave flow is again completely "deundulated." If the stroke frequency is greater than is required for the body length (e.g. in case of the start of flight), then the still unused roll eddies remain as "standing" eddies behind the tail end. They are then dissipated through internal friction (heat radiation to the water). Behind the end of the tail quiet water then prevails; there is also no backwash such as occurs behind a ship's propeller.

The sinusoidal swimming path arising from the body stroke leads to the result that there can be no direct flow from the front, no stagnation point and no body resistance. Thus in the case of forward motion in undulating flow there can also be no flow resistance increasing with the square of the velocity which must be overcome by a propulsive output growing as the cube of the velocity, as is the case with ships and airplanes. Therefore, in the case of forward motion in undulating flow a different law of flow holds, according to which, the required propulsive output apparently grows in direct proportion to the increase in the velocity.

The energy consumption required for the propulsive output in the case of forward motion in undulating flow, which is almost exclusively involved in the rotation of the "roller bearing" on both sides, is thus relatively small. Only in this fashion can one explain the phenomenal swimming achievement of dolphins.

A special case of propulsion without individual muscle power or expenditure of energy is the "wave riding" of the dolphins in the bow wave of ships, and also on waves produced by the wind and surf, which has been observed by ships' personnel or coastal residents. This is in keeping with a permanent body downstroke and therefore with the skillful utilization of the hidden energy of the waves for propulsion by means of the inherent body weight (force of gravity). Wave riding is comparable with the gliding and soaring flight of birds, which should be more thoroughly explained as "special wave propulsion". A further special case is the water dance -- recognized as a training act -- which for purposes of observation might also occur in nature. It corresponds to the whirring flight of the hummingbird or of insects.

Thus the dolphin's manner of swimming is a rewarding object of study for the bionics specialist and the engineer, and the technical conversion and application of its operating principle is a worthwhile goal.

## II. The Flight of Birds and Insects

The long-tailed swallow found along coastal waters of northern Canada flies in the autumn over 17,000 km along the coast down to the Antartic, and in the spring it again flies 17,000 km up to its arctic home. Albatrosses which follow ships for days over the southern oceans are able to keep themselves soaring in stormy air for hours without a single wing beat. American zoologists have established that hummingbirds fly from the American coast 800 km over the ocean to the Yucatan peninsula with a 2 g subcutaneous fat layer as "propellant": indeed of these 2 g, 0.5 g are included as "fuel reserve" in case unfavorable winds hamper the flight. A flock of hummingbirds, one of which had been ringed in Cumberland, England, flew in December 1927 without rest 3500 km over the North Atlantic from England to Newfoundland, and this was achieved with a velocity of approximately 145 km/hr against the prevailing west winds. In the Pacific instances are known of non-stop bird migrations over a distance of 6000 km! The zoologist Stuart Baker claims to have recorded with a stop watch a velocity of up to 320 km/hr in the case of asiatic swifts. Doves are said to have attained velocities of up to 285 km/hr. And even the small dragon-fly can achieve peak velocities of over 60 km/hr. -- Numerous additional examples can be found in the professional literature.

Where does the bird or the winged insect obtain the requisite energy for such performances? According to the known laws of flow, such enormous outputs are not possible. Scientists have calculated that in accordance with the necessary propulsive output in direct flow, migratory birds would have to produce in fuel while underway a multiple of their body weight. Thus as far as the economy of flight is concerned, a bird or a winged insect consumes obviously relatively far less energy than an airplane. This is only possible when there is success in compensating extensively for resistance. That this is not merely a question of an "elastic skin," as M. O. KRAMER and other scientists assume in the case of dolphins /10/, is shown by the numerous examples of birds and insects.

No less a person than the previously quoted James Gray wrote in 1959 that the flight of birds is one of the greatest masterworks of nature, and that nature preserves most strictly the secret of bird flight /11/.

Indeed since ancient times mankind has attempted to fathom the secret of the flight of birds. Gustav Lilienthal and many other soaring glider builders have copied unsuccessfully the wing-stroke; even today such attempts are made, which however only testify to ignorance of the essential operating principle of bird flight and its technical conversion and application. Nature does not furnish any structural drawings which can be blue-printed.

On the other hand, even the theorems of aerodynamics which hold for propeller-driven airplanes or jet aircraft give no satisfactory explanation for the efficiency of the flight of birds, which, just as in the case of the dolphin's high-speed swimming, has not yet been approximately attained technically. Although the conventional airplane appears purely externally to imitate the flying bird, nevertheless the jet propulsion of the aircraft and the manner of flying determined by it have nothing in common with the flight of birds. On the contrary, they are entirely different, indeed antagonistically so. The propulsion of an airplane, regardless of whether propellers or jet-turbines are involved, rests, like the propulsion of a rocket, on the "reaction principle," the repulsion of air masses. The reflected wave which causes the forward thrust, is for the most part waste energy. By means of the reflected wave, the airplane is thrust forward rectilinearly, and thus so to speak, "by force," against the flow resistance. As the flight velocity increases in <u>rectilinear</u>

flow, the flow resistance increases quadratically, and the required propulsive output increases as the third power. Therefore the aerodynamicists strive to reduce the flow resistance by means of the smallest possible body cross-section and laminarization of flow (streamlining). Consequently an airship with its large body cross-section is at a hopeless disadvantage in rectilinear flow in contrast to the airplane: this handicap has caused the Zeppelin airship to be defeated and to succumb in the capitalistic competition struggle with the airplane.

Recognizing the fact that the laws of hydrodynamics also hold by analogy for aerodynamics, the suggestion is immediate that the same operating principle which holds for the propulsion of dolphins, whales and fish, is also valid for birds and winged insects. Of course in the latter case there are modifications which are primarily determined by the differences in the density of the media water and air. This is also the reason why the natural wave propulsion of birds and winged insects is not so clearly recognizable as is directly the case for dolphins. The wave propulsion of birds and winged insects is nonetheless as perfect as that of the dolphin.

The flights of birds and insects are also to the same extent propulsion in undulating flow as the manner of swimming of dolphins, whales and fishes. If one analyzes in greater detail the flight of birds and insects, then one finds an unmistakable analogy to the Dolphin Principle. The significant, but only superficial, difference which is caused by the vastly less density of the air instead of water "environment," lies in the fact that the dolphin represents an obvious unity of body and propulsive mechanism, whereas for birds, although this unity is present, corresponding to an environment of a different kind, it is not immediately apparent to the layman, however. Moreover vastly greater importance than in the case of the dolphin attaches to the relationship between weight and "buoyancy" in accordance with the Principle of Archimedes, because of the considerably smaller density of air as compared to water.

What the body-tail stroke is for the dolphin, the beating of the wing is for the flight of insects and birds. On the up and down beating wing analogously the same processes occur as on the up and down whipping dolphin's body. The dolphin-bird (insect) comparison is rendered more difficult principally by the fact that the body-tail stroke of the dolphin has a uniform amplitude (stroke width) in the transverse direction, while the amplitude of a bird's wing at the wing root equals zero and is greatest at the wing tip. From this fact there emerges a multitude of peculiarities whose explanation and clarification would fill an entire book. If one abstracts from them, then one obtains the ideal case as in the case of the dolphin, as though the wing has over its entire length (spread) a uniform amplitude. This is then the fact also which one must provide for the technical conversion and application of natural wave propulsion by means of the wave propeller.

Figure 4 shows a bird's wing in the case of the down-beat; here the trailing edge of the wing, swings and bends elastically (analogous to the dolphin's tail stroke) upwards. On the other hand, in the case of the up-beat of the wing, the reverse process occurs: the trailing edge of the wing bends elastically downwards. Thus the wing beat generates, analogous to the dolphin's body stroke, a "roll eddy" on the leading edge of the wing, over which the wing "rolls", and which likewise "deundulates" itself on the trailing edge of the wing, thus ceasing to exist. In the case of low-speed flight (soaring) the wings are spread out wide and as narrowly as possible. For high-speed flight a bird can change the cross-section of its wing and thus withdraw it to the rear, so that the wing chord is enlarged and the "roller bearing" is lengthened. Swallows, which are definitely high-speed flyers, thus have wing and tail feather ends which are bent backwards extensively and function as long "roller bearings" and consume optimally the invested energy, converting it into forward thrust. The speedy dragon-fly possesses an oppositely-beating second wing which provides for the "deundulation", and thus ensures the optimal utilization of the propulsive energy. In exactly the same manner as the dolphin's body is propelled on a sinusoidal swimming path, the bird's wing moves forward on a sinusoidal flight path (Figure 5). Thus flow resistance on the bird's wing also cancels out. Also in no case does the bird's body move forward in rectilinear, resistance-creating flow. In textbooks it is frequently stated -- and individual observations confirm this -- that, e.g., swallows glide unsteadily with slow, wide-spread wing strokes in a smooth wave line /12/.

Many birds (sparrows, titmice, etc.) have a special, "wave-like" kind of flight. Swans seesaw with outstretched neck and their bodies move on a smooth wave path. Because of the low density of air compared to the density of water as well as the relatively low velocity, such a "smooth wave path" suffices largely to eliminate the flow resistance of the bird's body.

Just as the dolphin in the case of wave riding (and probably all the more so in the case of turbulent flow below the surface of the water -- which we have been unable to observe up to now), the bird is able to transform flow energy to an even greater extent into propulsion by means of his body weight, without requiring muscle power. The gliding flight of the bird is nothing more than a permanent body and wing downward stroke. In this special case the body and wing of the bird form a total lifting surface; the wings as well as the trunk of the bird form by means of the same transverse flow a "roller bearing" through which they roll. In the process the wing tips are swung downward so that the wings and the body have the same chord and thus maintain "roller bearings" of equal length (Figure 6).

If the energy of the transversal flow is equal (by virtue of upwind on a mountain slope, a thermal, turbulent flow over the water or behind ships) to the force of gravity acting as "propulsion," then the bird can soar at a constant height. If the flow energy is greater than the force of gravity, then a gain in height is even possible. The bird can thus regulate this through a change of his wing cross-section (Figure 6), whether he wishes to soar or glide, rise or fall, and all of these faster or slower.

Highly efficient soarers require narrow and extremely long wings since they must utilize a small flow velocity, and therefore for a large wing chord the roll eddies do not contain enough rotational energy to remain effective.

Thus the bird utilizes gravity together with the force of the wind (indirectly the energy of the sun converted into motion which here, as it were, is applied as "propellant") instead of muscle power when gliding and soaring.

The whirring flight of birds and insects constitutes a peculiarity which one can observe in its most pronounced form in the case of hummingbirds. It is "standing flight." Instead of beating up and down, the wing beats forward and backward so that an upward propulsion results. The frequency of the beat is in this instance so great that no complete deundulation is possible and a turbulent air jet behind the bird flows off. Such a drive expends energy and is possible only for super-light flying animals weighing up to approximately 20 g (insects, hummingbirds, nectar suckers, regulidae). Nevertheless a wave drive in which primary suction is generated upwards is more economical than a lifting-jet drive.

## III. The Technical Conversion and the Possibility of Applying the Dolphin Principle in Aeronautics

Proceeding from the drive of an aircraft, whether reaction drive (propeller, jet turbine, or rocket) or wave drive (gravity/wind energy or wave propeller) one must fundamentally distinguish

a) aeronautics in direct flow

b) aeronautics in undulating flow.

In the case of aeronautics in direct flow, the flow generates on the aircraft a flow resistance which increases as the square of the flow velocity and which must be overcome with a propulsion output that grows as the cube of the velocity. The shock wave behind the aircraft, which attains a very considerable intensity in the case of large aircraft and is intensified with increasing flight velocity, is lost energy. The reaction drive has therefore a relatively poor working efficiency. In the case of aeronautics in undulating flow, on the other hand, the flow on the aircraft generates a propulsion which increases with the velocity of flow. In the case of a correct ratio between the stroke frequency and the wing chord of the aircraft there is no unproduced wave-energy behind the aircraft and thus no waste energy. In the ideal case the installed energy of propulsion minus the rotational energy of the roll eddies consumed by internal friction is completely utilized for propulsion (forward thrust including upward thrust). In the case of propulsion in an undulating flow there is moreover no flow resistance, so that as the velocity increases the required propulsive output should increase approximately in direct proportion only. Thus the wave drive would have a relatively high efficiency.

The laws of flight mechanics for conventional aircraft in direct flow have been extensively researched and are well-known. On the other hand the laws of flight mechanics in undulating flow have been applied up to now only in the case of gliding and soaring flight; as a result they are being adapted to and incorporated into the mechanics of flight in direct flow in ignorance of the real operating principle of flight in undulating flow.

KNOLLER (1909) /2/ and BETZ (1912) have already endeavored to clear up the manner of flight of birds soaring without up-drafts as "an apparent contradiction against basic theories of mechanics" /3/. These theoretical starts as well as the practical experiments of Katzmayr (1922) remained bogged down in the beginnings since they did not uncover the real action principle. The experiments with impact rudder drive later on only yielded an efficiency of about 50%, worse than the efficiency of propellers. In 1942 W. SCHMIDT succeeded in proving experimentally that a rigid wing inserted behind the impact rudder generates a supplemental thrust /13/. In 1959 W. SCHMIDT again improved the impact rudder drive; the rotating, up and down moving agitating arm -- the wave propeller -- was originated /4/. The discovery of the Dolphin Principle and the knowledge about the possibility and necessity of aeronautics in undulating flow lead in 1968 to the founding of the Kdt-Operations Commission for the Study of Air Travel /5, 7, 14/. Since then an intensive research effort has been carried out on a team basis. Numerous experiments with models have been conducted, new knowledge concerning aeronautics in undulat-flow has been gained, the wave propeller has been further developed through the introduction of elastic wave blades, and a number of patents for aircraft on the basis of the Dolphin Principle have been acquired /1, 15...26/.

The technical conversion of the Dolphin Principle and its application in aeronautics is possible for gliders, power gliders and VTOL-sport aircraft, for fixed-wing aircraft, above all for large capacity aircraft, for lifting jets with wave drive, for crane and heavy-duty airships as well as for dolphin airships. The application to ground-effect machines as well as to watercraft is likewise possible; however this must await special investigation.

## Soaring Flight

Gliding and soaring flight initiated by OTTO LILIENTHAL in 1891, was successfully continued by the WRIGHT brothers, CHANUTE and HERRING in the USA; VERSHIN, DOBROVOL'SKIY, SHUKOVSKIY, TUPOLEV and ANTONOV et al. in Russia; and by thousands of other flight pioneers in numerous lands. In 1911 GUTERMUTH with the Darmstadt gymnasts and students carried out glider flights on the Wasserkuppe [Rhone] for the first time, and OSKAR URSINUS and the Rhone sailplane pilots have since 1910 finally secured international standing for soaring flight as a sport, if the birds are left out of consideration.

The developmental history of soaring flight shows how the pioneers of this kind of flight have succeeded step by step through continual experiments in mastering the tricks of the flight of birds, e.g., hang gliding, flight in cloud and dry thermals, steep-angle circling, soaring in wind thermals and surfing. In ignorance of the real operating principle of the flight of birds, however, the knowledge acquired has been theoretically "fitted" into the aerodynamics of the airplane wing in direct flow.

Soaring flight, including the newly arisen gliding flight with Rogallo kites is flight in undulating flow. Deliberate application of the Dolphin Principle in the sport of soaring flight could bring about a revolutionary development, the combination of the soaring flight and the wing stroke of the bird. This would translate into reality the dream of the glider pilot -- the power glider for roving the air. Previously in 1924 there were experiments for this purpose with the "Chemnitz power glider" as well as with WOLF HIRTH'S "Mosis Hi 20": they attempted to solve the problem with a collapsible propeller -- thus by means of flight in direct flow.

A solution analogous to the flight of birds in undulating flow -- gliding, soaring as well as wing stroke in calm air -- would be entirely conceivable by means of a new kind of glider with wave propulsion on the surfaces. Two versions are conceivable here:

a) Wave propulsion only on the leading edge (Figure 7);
b) Wave propulsion on the leading and trailing edge of the wing (Figure 8).

When soaring in feathered pitch the waves could serve simultaneously as front and rear wing and thus as supplementary lifting surface. Then the lifting surfaces, provided with vertical fins, could be built shorter and deeper. With such a glider having wave propulsicn, one could glide, soar, or in calm air propel oneself with "beating wings." As a third alternative a sport airplane "Dragon-fly" would also be possible, which, like the dragon-fly, would possess a "double undulator" as lifting surface. This would solve the problem of the ornithopter. The glider with wave drive would start under its own power: neither rubber cord, winds nor tow airplane would be required. Off-field landings with time-consuming, expensive return trips by truck would be unnecessary; the glider pilot could fly back under his own power to the home air base.

## Airplanes with Wave Drive

In view of the technically highly developed jet airplanes for the sub- and supersonic region it seems at first absurd to propose an airplane with wave propeller. Nevertheless there are several points of view which are worthy of serious examination.

The aircraft with wave drive proposed by W. SCHMIDT in 1964 /27/ were based on the obsolete notion of the single tail fin drive. With the discovery of the Dolphin Principle unifying body and tail stroke, it is at this stage possible to develop rigid-wing airplanes for the purposes of airtravel in undulating flow. Their great advantage would be that in the case of a large body volume they would exhibit only a fraction of the flow resistance of equally large airplanes of conventional design. A much greater fuel economy is however not the sole advantage of an airplane with wave propulsion. The application of the wave drive makes it possible not only to design the airplane wing thick, especially deep, and therefore relatively short, but this is also required in order to prevent oscillation or fluttering of the lifting surfaces. The adjustability of the undulating blades from lift to forward thrust, and conversely, as well as the large chord of the airfoil wing makes possible vertical take-off and landing (VTOL) without the necessity of a propulsive-unit -- or indeed wing-oscillation, as is required with VTOL airplanes with propeller drive (e.g. Vought XL 142 A/USA). In contrast to lifting-jet airplanes with TL propulsive units, the airplane with wave propulsion offers not only the advantage of much lower fuel consumption, but also that of a cold jet instead of a jet of hot gasses.

But especially advantageous is the application of the wave propulsion in the case of an all-wing airplane, which, in its basic form, would correspond to the dolphin airship (Figure 10). Since through the interaction of bow and stern undulator the profile resistance is substantially eliminated, such an airplane could be designed on a large scale (thickness, width and depth) and with very satisfactory wing loading.

In order to raise the power output of the propulsive unit as well as the lateral stability for heavy duty airplanes one could mount supplementary "satellite dolphins" on both sides of the vertical fins, each of which would be equivalent to approximately half the length of the fuselage dolphin. According to design, each fusilage would be 20 to 50 m wide and 50 to 100 m long; the thickness about 10 to 20 m. The forward undulators would have a diameter from about

3 to 5 m, the stern undulators, about 2 to 4 m. In the lower parts of the end and intermediate supports, which would have to be about 2 m high, sufficiently stationary wheels could be installed which during landing could be driven in approximate synchrony with the landing velocity in order to avoid abrasion damage on touch down. Retraction of the wheels during flight would be inapplicable since instead, the fairing of the end and intermediate supports would be drawn up. The satellite dolphins on both sides would be accessible for inspection during the flight and moreover they could carry larger amounts of fuel (e.g., liquid hydrogen as possible alternate fuel) (Figure 9).

The heavy duty airplane with wave propulsion could be designed for a payload of up to 1000 t. However it should only be employed for cargo and freight transportation. The pilot's cockpit by itself could then be catapulted out and land by parachute in an emergency on take-off or landing. For mass passenger service one should on principle use the dolphin airship for reasons of safety.

The airplane with wave propulsion is not supposed to replace the jet airplane, but perhaps supplement it in some areas of use.

## The Crane and Service Airship with Wave Propulsion

The crane and service airship has already been described in detail /20, 26/. The basic form is likewise that of the dolphin airship (Figure 10). The crane airship can be raised several levels when coupled compositely; moreover by means of supplementary lifting undulators in the vertical fins and on the intermediate supports it can be augmented. A special form which possesses for a large gas volume the smallest possible diameter and the greatest stability would be a "spherical airship"; it can be flattened down to a "disk airship".

The crane and service airship is intended to supplement the crane helicopter in the payload range from 5 to 500 t. It can also be operated in the small payload range from 1 to 20 t without gas hull as "lifting jet with wave propulsion." In the large payload range over 20 t a lifting gas charge which eliminates the dead weight (circa 70% in the case of a helicopter) is recommended. The crane airship operates with vertical take-off as does the crane helicopter with a lifting jet; however it has undulator blades instead of rotor blades. Just like the helicopter, it maneuvers easily. The most essential advantage of the crane airships with wave propulsion are:

1. The crane airship can hover so that the output of the propulsive unit is used only to lift the payload.

2. In contrast to the crane helicopter, which has available at most two rotor circles, the crane airship can be equipped with an arbitrary number of wave propulsion units. Whereas the helicopter always "washes" the fusilage, the undulator blades always have a free radiation. Several undulators can be arranged over each other so that the lift is substantially reinforced.

3. The crane airship is materially more stable in flight than the helicopter which is reative to the wind and to swinging; it can even "swallow" a strong wind through its undulators.

Therefore the crane and service airship with wave drive is of great value for the national economy; to it falls the pioneer role in the introduction and development of travel by dolphin airship in the coming decade. It can perform work of incalculable value on the building sites of communism.

Travel by Dolphin Airship

The proper and most important area of application in connection with the technical conversion of the Dolphin Principle in aviation belongs to the "dolphin airship" (Figure 10) such as is being tested and developed at present in an experimental model in the Kdt-Operations Commission for the Study of Air Travel (Team Research and Development Bureau for Air Travel). This is not simply a copy of the natural dolphin, but the most extensive and comprehensive technical conversion of the Dolphin Principle (Figure 11).

Thus there came into being a totally new kind of airplane which combines in itself the advantages of the helicopter, the airplane and the airship. Comprehensive descriptions of its advantages in comparison to other means of transportation, its new capabilities for uses not possible with other means of transportation and its great importance for the national economy are available /1, 5, 15, 23, 24, 25/, so that for reasons of space we can refrain from repeating them here.

With experimental models it was established that the airfoil wing form (dolphin airship) in an undulating flow of drop form (Zeppelin) is far superior; for the same voluem and the same propulsive output the dolphin airship makes possible not only a substantially higher velocity, but also possesses a twenty times greater dynamic lift than the Zeppelin form /1, 19/.

The vertical fins and intermediate supports serve simultaneously as mounting and support for the undulators, they serve to raise the stability of the fuselage, to control the wave flow, prevent an induced resistance, improve the lateral stability and to incorporate the elevator and rudder pedal.

The bow undulator fulfills the function of the body stroke; it generates up to 50% of the invested motive energy of the primary propulsion and provides for the flow across the hull of the airship which is necessary to develop the wave flow (roll eddy). When sufficient wave flow is generated (adjustment of the rotational frequency of the undulator with the fuselage cord), there arises on the airship hull a supplementary secondary propulsion instead of the usual flow resistance as in the case of direct flow.

If the stroke frequency, and thus the transverse flow, is too small, then a sufficient wave flow (roll eddy) cannot form and the airship hull travels in direct flow and experiences a corresponding flow resistance.

The stern undulator fulfills the function of the tail fins of the dolphin: it causes a positive suction on the stern which activates the "unrolling" wave flow so that it prevents a change from laminar to turbulent flow and hinders form drag, and instead it generates propulsion. The stern undulator, which on the one hand serves to deundulate as much as possible the residual wave flow of the stern undulator, also is used as elevator and wing flap (Fig. 11).

All the undulators can be converted while underway into uplift, drag, and downwards thrust by means of sun-and-planet gears. By means of individual adjustments in the standing hover or when traveling slowly, it can simultaneously assume steering functions, such as one finds in nature in the case of insects /28/. A lateral shift also in the case of erecting-crane operations in the air is possible by means of undulator and lateral rudder.

Thus the dolphin airship represents a unity of fuselage and drive; it conforms fully to the operating principle of the dolphin.

The dolphin airship will be in a position to supplement the previous means of transportation in many areas of operation: it will only assume tasks which it can carry out more economically, better, or in general as the sole means of transportation only. To the numerous new transport capabilities which can be carried out solely with the new means of transportation "dolphin airship" belong among others the transporting of heavy loads for building construction and industry. The dolphin airship has a flying range from standing hovering (by means of aerostatic uplift as well as aerodynamically by means of the lifting capacity of the blades of the undulator, i.e., by means analogous to the whirring flight of hummingbirds and insects) up to more than 500 km/hr; as heavy-duty airship it could transport payloads of up to more than 10,000 t (e.g. oil, wood or minerals from inaccessible taiga or arctic regions)(Figure 12). Due to the subdivision of the supporting body into lifting gas cells the dolphin airship is practically crash and fire proof as well as weatherproof, provided the building, safety and operating regulations are adhered to, and it can conduct off-field landings anywhere with safety; therefore in heavy-duty airships even the use of atomic propulsion is unobjectionable.

The introduction of travel in dolphin airships presupposes a stage of scientific, engineering and production development which has not been attained until today. However, the development and construction of dolphin airships pose numerous new problems whose solution will exert an influence on other areas of the national economy, just as previously the development of air travel had a fructifying effect in return on the further evolution of technology. Therefore the development of air travel by dolphin airship is a challenge which even today still demands of our young scientists and engineers a genuine pioneer achievement; it cannot be accomplished by one country alone, but it must be realized in cooperation with the Soviet Union and the other countries of the socialist community of states.

## FIGURES

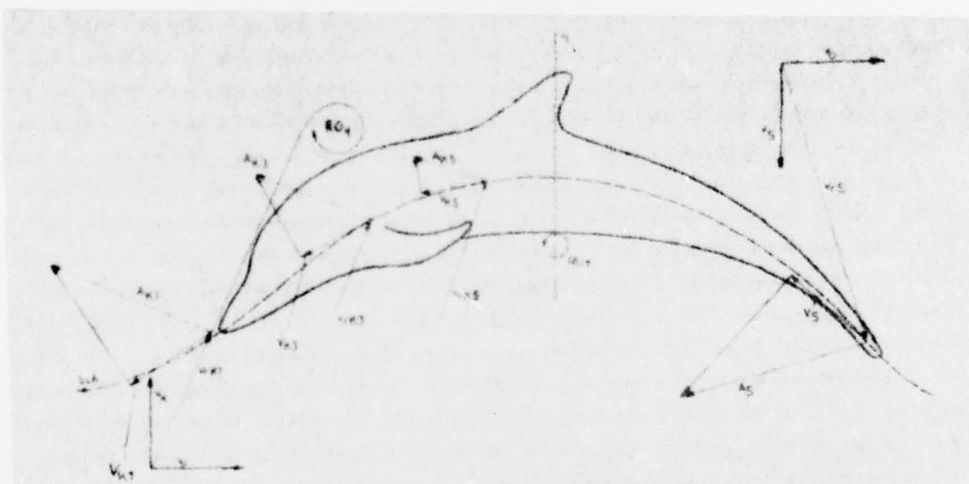


Figure 1. Body and Tail Stroke of the Dolphin (Downward Body Stroke)

- $v_o$ - Flow from forward motion
- $v_K$ - Flow from downward motion due to body stroke
- $v_{rK}$ - Transverse flow resulting from $v_o$ and $v_K$
- $A_K$ - Resultant flow force from body stroke downward
- $A_S$ - Resultant flow force from tail stroke upward
- $v_S$ - Oncoming flow from upward motion due to tail stroke
- $v_{rS}$ - Oncoming transverse flow due to $v_o$ and $v_S$
- $v_{K1..3}$ - Propulsion from body stroke ($V_S$ - from tail stroke)
- $RO_{1...25}$ - Roll eddy on the upper side of the body
- $RU_{1...25}$ - Roll eddy on the underside of the body
- D - Axis of rotation; Sch - Swimming path

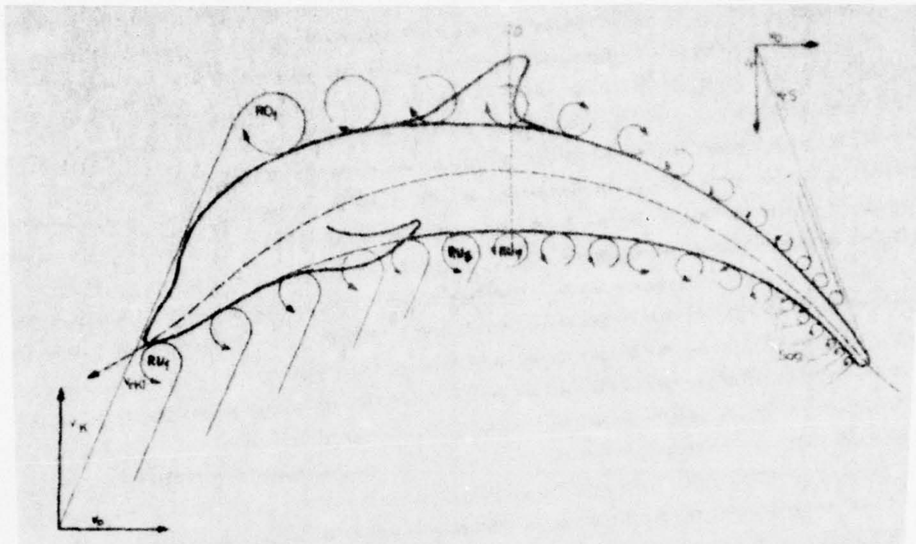


Figure 2. Flow around the dolphin's body in the case of a downward body stroke. Directed turbulence forms oppositely directed "roller bearing": on the back, clockwise; on the belly, counterclockwise. (Same desginations as in Figure 1)

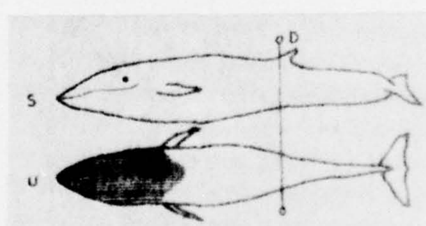



Figure 3. Side View and Top View of a Whale.

S - side view; U - underside;

D - Axis of rotation between the body and the tail stroke

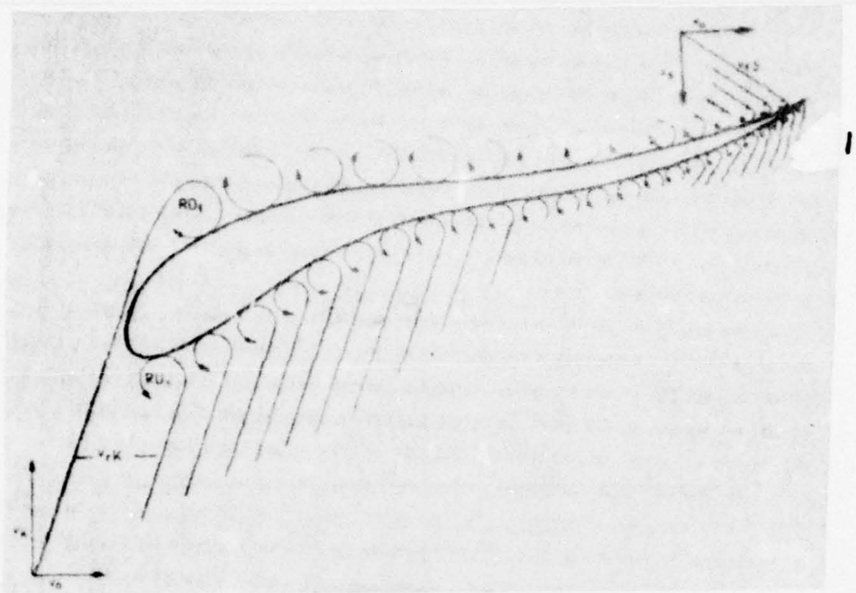


Figure 4. Downward Wing Stroke (Symbols the same as in Figure 1)

Key: 1 - Suction

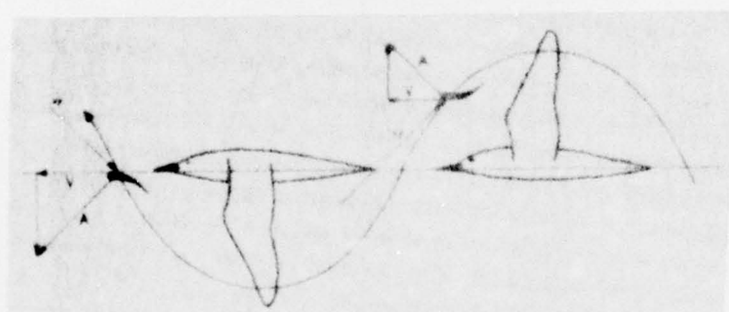


Figure 5. Sinusoidal Path of the Wing Stroke during Forward Motion

$v_r$ - oncoming transverse flow resulting from forward and downward or upward movement of the wing

A - resultant flow force; V - propulsion

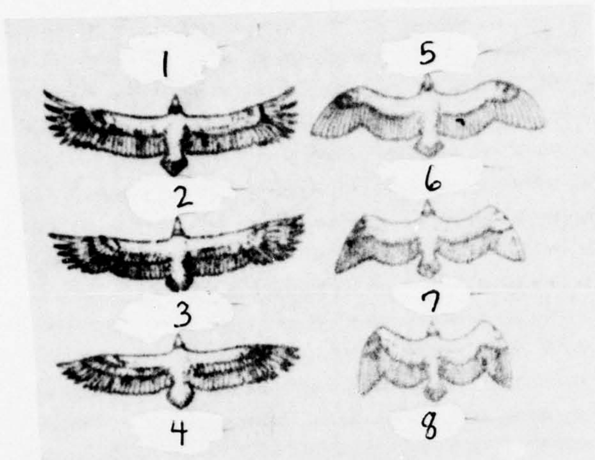



Figure 6. Variable Wing Layout: Soaring-Gliding /8/

Key: 1 - soaring; 2 - climbing; 3 - horizontal; 4 - dropping; 5 - gliding; 6 - level; 7 - normal; 8 - steep

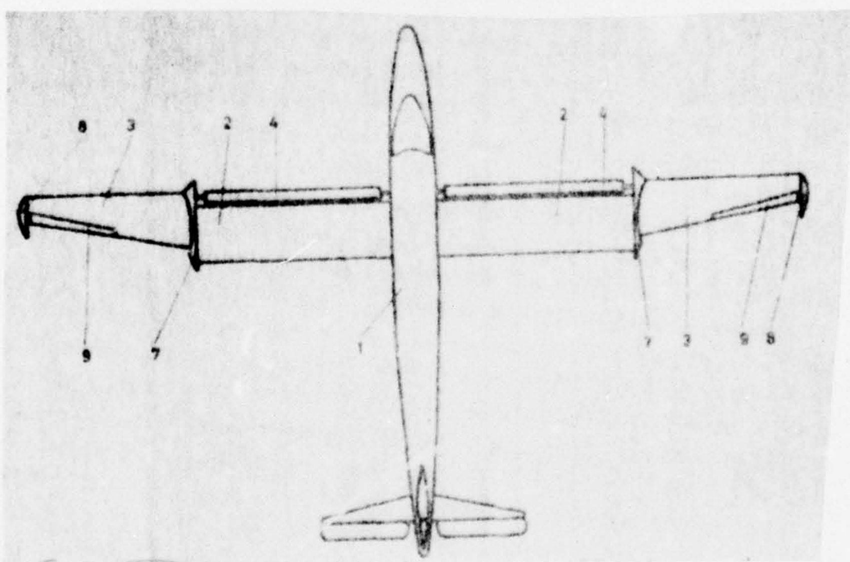


Figure 7. Roving Sailplane mi: Wave Drive on the leading Edge

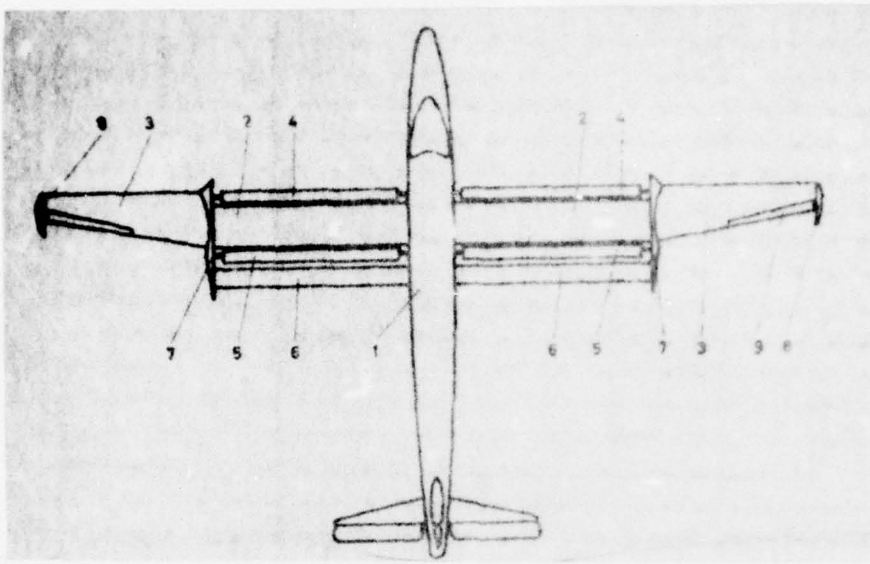


Figure 8. Roving Sailplane or Sportplane (VTOL) with Wave Drive on the Leading and Trailing Edges

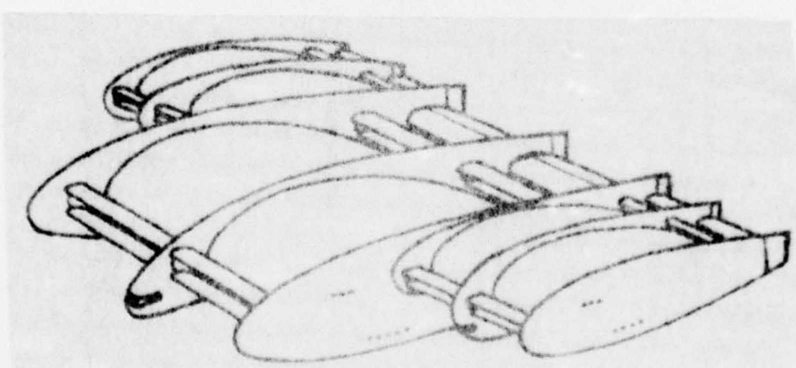


Figure 9. Heavy Duty Airplane with Wave Drive (Diagram)

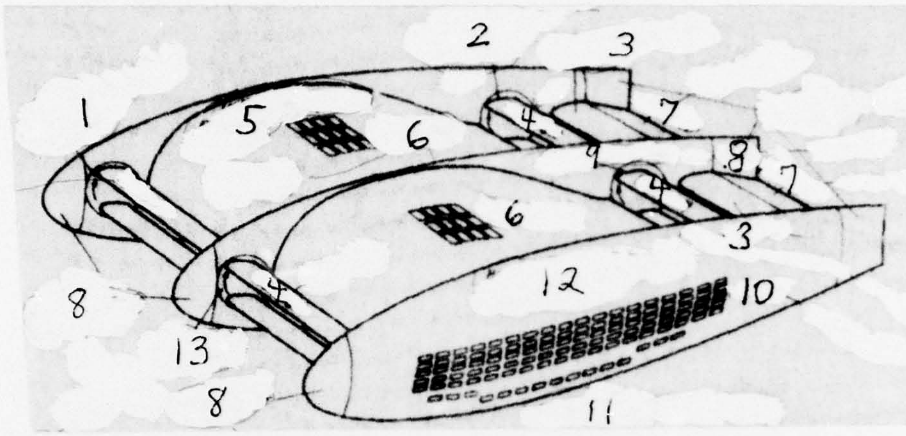



Figure 10. Diagrammatic Sketch of a Dolphin Airship /1/

Key: 1 - right hand bow undulator; 2 - right hand stern undulator; 3 - deundulator; 4 - undulator blade; 5 - airship fuselage with gas (helium) cells; 6 - sun deck; 7 - elevator; 8 - side rudder; 9 - left hand stern undulator; 10 - cabins; 11 - observation deck; 12 - semi-tear-shaped vertical fin; 13 - left hand bow undulator

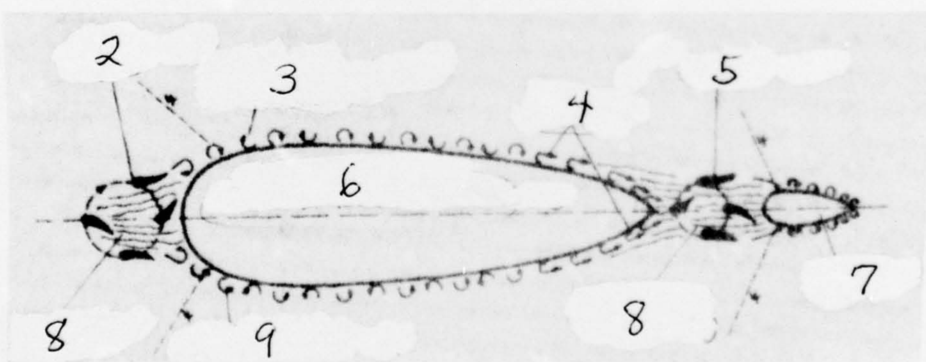



Figure 11. The Technical Conversion and Application of the Dolphin Principle on the Dolphin Airship.

Key: 2 - bow undulator; 3 - roll eddy (upper side); 4 - negative suction; 5 - stern undulator; 6 - airship fuselage (deundulator with large chord); 7 - deundulator; 8 - positive suction; 9 - roll eddy (lower side)

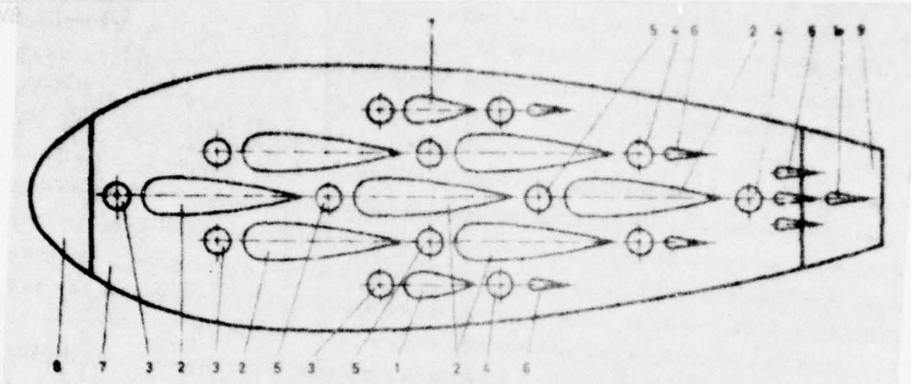


Figure 12. Diagram sketch of a cargo airship for heavy duty transportation of a payload in excess of 1000 t with atomic drive. 1, 2 - gas carrying hull; 3 - bow undulator; 4 - stern undulator; 5 - intermediate undulator; 6 - de-undulator; 7 - vertical fin or intermediate support; 8, 9 - rudder assemblies; 10 - elevator.

References


Luftschiff,

1. Queck, U./Schmidt, W.: Das Delphin-Luftfahrtbin gewellter Strosung. - Technisch-ökonosische Informationen der zivilen Luftfahrc (TIXL) Bin-Schönefeld 6 (1970) 5, S. 247 ... 258.

2. Knaller, R.: Die Gesetze des Luftwideratandes. - Flug- und Motortechnik (Wien) 3 (1909) Nr. 21, S. 1 ... 7 und Nr. 22, S. 1 ... 6.

- Zur Theorie des Segelfluges. - Zeitachrift fur Flugtechnik und Motorluftschiffahrt 4 (1913) 2, S. 13 ... 14.

3. Betz, A.: Ein Beitrag zur Erkarung des Segelfluges. - Zeitachrift für Flugtechnik und Motorluftechiffahrt 3 (1912) 21, S. 269 ... 272.

4. Schaidt, W.: Der Wellpropeller - ein neuertiger Antrieb für Landwirtechaftsflugzeuge, Luftkissenfahrzeuge und Flugautos. - TIZL 2 (1965) 6, S. 57 ... 67.

5. Queck, U.: Prognose der Luftechiffahrt. - TIZL 5 (1969) 2, S. 82 ... 103.

6. Gray D.: Studies in animal locomotion: The propulsion powers of the dolphin.- Journ. Exp. Btol. Bd. 13 (1936) S. 192 ... 200.

7. Delphinluftschiff mit über 500 km/h Reisegeschwindigkeir Nauarervorechiag [elligible - could be mispelled] von U. Queck vom 16.12.1968 an des Ministerium für Verkenswesen der DDR (Zentrales Büro für Nauarerwesen). [elligible - could be mispelled]

8. Hertel, H.: Struktur, Form und Bewegung. - Mainz: Kraüsskopf Verlag 1963.

9. Lagwinowitach, G. W.: Hydrodynamik der Schwizebewegung [elligible - schwimmbewegung?] der Fische. - Nachrichten der Sibirischen Abtailung der Akademie der Wissenschaften der UdSSR (Filiale des Zentralen Aero-Hydrodynamischen Instituts "Prof. N. E. Shukowski) Serie Technische Wissenschaften, Folge 2. Sonderdruck. Verlag "Nauka", Sibirische Abteilung 1973.

10. Kramer, M. O.: The Dolphins secret. - New Scientist (elligible) (London 1969). S. 1118/20.

11. Gray, J. How animals move. - Pelican Books A 454, Harmondsworth, Middlesex: Penguin Books Ltd. 1959, S. 133.

12. Rietschel, P.: Des Tierreich nach Brene. - Berlin/Jans: Urania-Verlag 1956 (Lizenzausgabe Berchteagaden: Verlag Zimmer u. Herzag 1955) S. 409.

13. Schmidt, W.: Reichstein, G.: DerKnoller-Betz-Effekt ele Mittel zur Erhönung des Wirkungsgrades von Schlagflugein. - Jahrbuch 1942 der dautschen Luftfahrtforschung, S. I 432 ... 434.

14. Protokoll Ober die 14. Berstung des Industriezweigvorstandes "Luftfshrt" a (elligible) 20.12.1968. - Berlin: Kammer der Technik, FV Fehrzeugbau und Verkehr, Industriezweigvorstand "Luftfahrt".

15. Queck, U.: Schmidt, W.: Das (elligible - could be mispelled) Delphin-Luftschiff, eine naue Theorie uber Luftfahrt in gewellter Strömung. - Moskau: NTO UdSSR (Nautschno - Technitecheskije obstachestws SSSR) 5/1971.

16. Schmidt, W.: Delphinluftschiff mit Wellantrieb, Ergebniese von Standschubmessungen am Modell 192 x 108. - TIZL 0(1973) 4, S. 240 ... 244.

17. Schmidt, W.: Delphinluftschiff mit Wellantrieb, Vergleich mit Hubschraubar am Stand. - TIZL 9 (1973) 5, S. 282 ... 285.

18. Schmidt, W. : Delphinluftschiff mit Wellantrieb neue Form der Wertigkeitezahl. - TIZL 9 (1973) 6, S. 351 ... 354.

19. Schmidt, W.: Delphinluftschiff mit Wellantrieb, dynamischer Auftrieb. - TIZL 10 (1974) 2, S. 104 ... 106.

20. Queck, U.: Delphinluftschiff mit Wellantrieb, vielseitig verwendbar als Kran- und Arbeitsluftschiff. - TIZL 10 (1974) 3, S. 161 ... 165.

21. Schmidt, W.: Delphinluftschiff mit Wellantrieb, Wirkung elsetiocher Wellerblätter. - TIZL 10 (1974) 4, S. 240 ... 242.

22. Schmidt, W.: Delphinluftschiff mit Wellantrieb, Vortriab von Entwellern großer Tiefe. - TIZL 10 (1974) 6, S. 56 ... 60.

23. Kurichin, O.: Die Geburt des Aero-Delphins. - Mcakau: Technika solodjoachi 10/1971, S. 13 ... 14.

24. Queck, U.: Schmidt, W.: Das Delphinluftschiff, eine neue Theorie über Luftfahrt in gewellter Strömung. - Berlin: Technische Gemeinschaft (TG) 10/1970, S. 28 ... 31.

25. Queck, U.: Schmidt, W.: Delphine der Luft, - Berlin: Flieger-Revue 6/1970, S. 226 ... 233.

26. Queck, U.: Delphin-Luftschiff ala Fliegender Kran. - Berlin: Fliegor-Revue 6/1974, S. 240 ... 241.

27. Patentschraft (Wirtschaftspetent) 34278 vom 15.12.1964. - Ast fur Erfindungeund Patentwesen der DDR.

28. Nachtigell, W.: Gluserne (elligible - could be mispelled] Schwingen. - Munchen: Hainz Moos Verleg, 1958.

TIZL 11 (1975) H.2.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER FTD-ID(RS)I-1330-76 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) THE DOLPHIN PRINCIPLE, ITS TECHNICAL CONVERSION AND APPLICATION IN AERONAUTICS | | 5. TYPE OF REPORT & PERIOD COVERED Translation |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) U. Queck | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Foreign Technology Division Air Force Systems Command U. S. Air Force | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS | | 12. REPORT DATE 1975 |
| | | 13. NUMBER OF PAGES 31 |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | | 15. SECURITY CLASS. (of this report) UNCLASSIFIED |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

01

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

| ORGANIZATION | | MICROFICHE |
|---|---|---|
| A205 | DMATC | 1 |
| A210 | DMAAC | 2 |
| B344 | DIA/DS-4C | 8 |
| C043 | USAMIIA | 1 |
| C509 | BALLISTIC RES LABS | 1 |
| C510 | AIR MOBILITY R&D LAB/FIO | 1 |
| C513 | PICATINNY ARSENAL | 1 |
| C535 | AVIATION SYS COMD | 1 |
| C557 | USAIIC | 1 |
| C591 | FSTC | 5 |
| C619 | MIA REDSTONE | 1 |
| D008 | NISC | 1 |
| H300 | USAICE (USAREUR) | 1 |
| P005 | ERDA | 2 |
| P055 | CIA/CRS/ADD/SD | 1 |
| NAVORDSTA (50L) | | 1 |
| NAVWPNSCEN (Code 121) | | 1 |
| NASA/KSI | | 1 |
| 544 IES/RDPO | | 1 |
| AFIT/LD | | 1 |

| ORGANIZATION | | MICROFICHE |
|---|---|---|
| E053 | AF/INAKA | 1 |
| E017 | AF/RDQLR-W | 1 |
| E404 | AEDC | 1 |
| E408 | AFWL | 1 |
| E410 | ADTC | 1 |
| E413 | ESD | 2 |
| | FTD | |
| | CCN | 1 |
| | ETID | 3 |
| | NIA/PHS | 1 |
| | NICD | 5 |