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NAVY DEPARTMENT

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Partial Report

on

Oils for Calming Rough Waters

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ABSTRACT

This report discusses a suggestion that synthetic oils be developed to calm rough waters to facilitate the aligting of seaplanes on the surface of the sea. By correlating physical-chemical data and theories with the results of practical experience it is indicated that the natural oils now used are probably the equal of any available synthetic oil for calming rough waters and that they would probably be of little value to airplanes except as storm oils when forced down at sea in heavy weather.

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AUTHORIZATION

1. This problem was authorized by reference (a); other references pertinent to this report are listed as references (b) to (d).

Reference: (a) Bu.C&R let. H1-15(S) of 12 Nov.1935.
(b) ONI Report Ser.No. 539, File No. 912, dated 9 Oct. 1935.
(c) Hydrographic Office Reprint of Hydrographic Information No.3, dated 24 April 1909: "Use of Oil to Calm the Sea".
(d) U.S.Naval Institute Proceedings Vol 59, p.681, 1933.

STATEMENT OF PROBLEM

2. This problem had its origin in the Office of Naval Intelligence report from the Naval Attache, Paris, ref. (b), which stated that in the course of experiments made by the Model Basin of the French Ministry of Marine some synthetic oils for calming rough water had been developed. In mkaing this report Captain J.A. Furer (CC) USN. suggested that the Bureau of Construction and Repair investigate these synthetic oils and moreover suggest some possible new applications of them of interest to the Bureau of Aeronautics, namely, their use by aircraft to facilitate the alighting on the surface of the sea. He was unable to learn the nature of the synthetic French oil. The problem therefore is to study the characteristics of oil for use in calming waves at sea for aeronautic and ship use and to develop synthetic oils for this use.

KNOWN FACTS BEARING ON PROBLEM

3. The use of oil to calm waves in stormy weather dates back to ancient times. The experience of mariners over several centuries has proved, in a qualitative way, that some oils are better than others and has indicated, for example, that animal and fish oils are for the most part better than vegetable oils and both are much superior to mineral oil, such as fuel oil. In the last several decades a large amount of experience in the use of oils for calming seas has been accumulated, principally through the efforts of the Hydrographic Office of the United States Navy. The Hydrographic Office files contain a large number of detailed statements concerning the methods of use and type of oil best suited to this purpose.

4. In the past sixty years various research chemists, principally in the United States and Great Britain, have been making comprehensive studies of the characteristics of liquid films on the surface of water. Their laboratory and theoretical studies have led to a detailed picture of the nature and properties of these films.

5. Small scale studies of effect of oil on waves were made in Scotland in 1882-1883 by Shields and Aitken. The former experimented in Aberdeen Harbor and showed clearly that the effect of oil was not to diminish the height of large waves but merely to smooth over the waves and thereby prevent the formation of dangerous crests. A dramatic example of the use

of oil to calm stormy seas is given by Lieut.Comdr. Giles Stedman, USNR., (ref.(d)) in his description of the rescue by the SS American Merchant of the crew of the foundering vessel Exeter City. With the wind blowing force 6 the sea at the time of the rescue had developed into a high confused swell which broke under the influence of passing squalls and would have made rescue work impossible unless oil was used.

> "The effect of the large amount of oil was quite remarkable and the area in which it was used was clearly defined from the bridge (55 feet above water). The swell which was streaked and dotted with whitecaps would reach the boundary of the oil and then flatten out, much in the manner of a loosely laid tarpaulin or carpet with a breeze bulging it in the center. The water between the two vessels was subdued, so much so that an attempt to float a lifeboat over could be made with a reasonable chance of success. ...."

> "..... It was noted at this time that both vessels had drifted into the oil spread out to the leeward, which now covered a large area in all directions. It was not, of course, the impressive thick covering that existed to windward, but there was not the slightest doubt of its reducing effect on the sea. ...."

> "The subduing effect of oil on sea cannot be too strongly emphasized. It made rescue work possible in the present instance. A total of 82 tons of fuel and 65 gallons of storm (animal) oil was used in a period of four hours. While the fuel oil is thick and congeals in cold water, the action of sea breaks it up, spreads it about, and soon increases its effectiveness. From the heights of the bridge, the oily area was clearly and amazingly defined. ...."

THEORETICAL CONSIDERATIONS

6. It should be pointed out at the outset that the theories which have been developed to explain the effects of oil films, laboratory and small-scale experiments, and practical experience all agree that oil films do not diminish the height of large waves already formed but that they damp out the small ripples and irregulatities which are being constantly formed by the action of the wind on these large waves. When these small ripples are not damped out, their cumulative action disturbs the surface and leads to the breaking of the large waves and it is this breaking action which is destructive to floating craft either by battering them to pieces or crashing them into floating or fixed structures.

7. A basic requirement for these oil films is that they spread upon the surface of the sea. Physical-chemical considerations define a simple criterion of the efficacy of a given substance for spreading on water. These show that a measure of the ability of a substance to spread is given by the spreading coefficient defined as follows:

$$S = T_W - (T_O + T_{WO})$$

where

T_W is the free surface energy of the water (surface tension),

T_o that of the oil, and T_{wo} is the interfacial tension of the film of oil on the surface of water. Thus the spreading power of an oil can be readily determined in the laboratory by well established experimental methods.

METHODS

8. If the theoretical considerations which have been applied to this problem are correct, it follows that it is not necessary to make such actual scale experiments as have been made by the French Model Basin, ref. (b), but that simple surface tension measurements made in the laboratory should suffice. Perhaps the simplest method for making these surface tension measurements is the commercially available DuNouy ring surface tension meter, (illustrated in Plate 1). In this the force required to detach a circular metal ring from the surface of the liquid gives a measure of its surface tension, while the interfacial tension of a film is similarly determined by the force required to detach the ring from the interface.

9. Experiments were made in dropping a number of oils on the Potomac River but it is difficult or impossible to gather quantitative data in this way.

DATA OBTAINED

10. Data on the surface tension and spreading coefficients of pure organic liquids are given in Table 1, while in Table 2 are given similar data for natural fish and vegetable oils.

CONCLUSIONS AND RECOMMENDATIONS

Facts Established

11. From the above discussion and from the data of Tables 1 and 2 it may be seen that the substances which physical chemical considerations would indicate are suitable for calming rough water are exactly those substances which centuries of practical experience have shown to be best. Other facts established are:

(a) The ability of a given substance to spread on water to form a ripple-damping film can be correlated with laboratory measurements.

(b) Petroleum oils have poor spreading characteristics.

(c) The best spreading liquids are those whose molecules have a long hydrocarbon chain with a polar group (a group which is soluble in water) at one end.

(d) Natural oils, such as fish, animal, and vegetable oils contain substances having this film-forming structure.

Opinions

12. It is considered that the question as to whether it will prove

profitable to produce a synthetic oil for Naval use in calming rough waters will be largely an economic one. It is probable that a synthetic oil having somewhat superior characteristics to the usual storm oils could be produced, but at greater cost. Natural products are, after all, a cheap source of the types of substances which are desired. Recently, however, an enormous number of new synthetic wetting agents have been produced. Many of these are proprietary substances of secret composition which might prove of value as film-forming agents. Then, too, the growing use of petroleum as a raw material in synthetic chemistry for the production of higher alcohols, esters, acids, etc., may lead to the production of cheap synthetic storm oils.

13. The above discussion throws some doubt on the utility of oil for calming rough waters to facilitate seaplanes alighting at sea. It is understood that the chief danger to planes in landing on the sea is from the larger waves which are not diminished by the action of oil. It is considered that the chief use of oil by airplanes would be as follows:

(a) Patrol planes forced down at sea by engine trouble.

Analogous to the use of oil for life boats at sea it is suggested that if a patrol plane were forced down in a heavy sea it could make use of a sea anchor and of oil let out to windward to diminish the damaging effect of the breaking waves. The amount of oil required would be small and its weight would not be a serious charge against the weight limitations of the plane. Thus it is estimated that a gallon of oil properly used would last for 24 hours. However, if the weight demand is considered excessive, the plane could use engine lubricating oil and improve its spreading characteristics by dissolving in it a small amount of fat, wax, or oil having a high spreading coefficient, since such addition increases the spreading characteristics of the petroleum oil.

(b) Calming the waves at the entrance to a sea plane harbor.

The use of oil might permit a patrol plane to enter a protected sea plane harbor under conditions which might otherwise be dangerous.

(c) Improving the effectiveness of landing canvas.

The use of oil might improve the slick behind a towed canvas and simplify the plane's reaching the ship.

(d) Coming alongside a ship.

It is considered improbable that the use of oil would improve the effectiveness of present maneuvers for taking sea planes aboard, wherein the ship executes a maneuver to form a slick on the sea surface upon which the plane lands. The use of oil might, however, increase the time during which this slick lasts.

Recommendations

14. From the above it is recommended that:

(a) The Bureau of Aeronautics consider the advisability of testing the use of storm oil by patrol airplanes forced down at sea.

(b) This Laboratory investigate some of the newer synthetic substances in the hope of finding a storm oil of maximum effectiveness.

Conclusions

15. From the discussion above it is concluded that:

(a) The use of oil to aid seaplanes in alighting at sea is probably of little value.

(b) Oil might prove of value to planes forced down at sea to minimize danger to personnel and damage to the plane.

(c) Present storm oils are nearly as effective as any synthetic oil which can be made at present.

(d) Storm oils act, not by diminishing the height of large waves, but by preventing their breaking.

(e) Laboratory measurements can forecast the utility of substances to form films for calming waves.

(f) Some improvement in storm oils may result from use of newer synthetic substances. These would probably be more expensive, but the weight restrictions on airplanes might justify the added cost.

TABLE 1

Surface Tension and Spreading Coefficients of

Various Organic Liquids.

Substance	Surface Tension	Interfacial Tension	Spreading Coefficient
Paraffin Hydrocarbons			
Octane	21.8	50.8	0.2
Liquid Petrolatum	31.1	55.3	-13.7
Primary Alcohols			
Heptyl	27.0	7.9	37.8
Octyl	27.5	8.5	36.7
Ketones			
Methyl butyl ketone	25.5	9.7	37.5
Ethyl propyl ketone	25.4	13.6	33.8
Acids			
Heptylic	28.3	6.6	37.9
Undecylenic	30.6	10.1	32.0
Oleic	32.5	15.7	24.6

TABLE 2

Surface Tension and Spreading Coefficients of

Various Natural Oils.

Oil	Surface Tension	Inter-facial Tension	Spreading Coefficient	Chemical Composition
Sperm	33	7.7	32	Mainly various high alcohols in combination with fatty acids of oleic series.
Turpentine	30	12	31	
Rapeseed	33	15	25	Mainly glycerides of various acids.
Linseed	33	17	23	Glycerides of solid fatty acids, liquid acids.
Castor	38	16	19	Chiefly glycerides
Almond	35	20	18	Fatty acids, mainly oleic.
Olive	37	21	15	Chiefly glycerides
Petroleum	32	38	3	Hydrocarbons

Plate 1 - P-1293

(No copies of Plate 1 are available at this time. If and when it is available it will be tipped in this place)