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A SELECTED BIBLIOGRAPHY OF FRENCH REPORTS IN THE FIELD OF AIRCRAFT ICING

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Introduction

As part of the arrangements for the course on Airplane Icing Information at the University of Michigan, March 30, 1953, a good deal of correspondence was carried on with Dr. Edmond Brun of Paris, France, who has been active in the ice prevention field since the early 1930's. He has supplied us with copies of pertinent French articles and the following list of reports is taken from his documents. Some reports have also been supplied by Mr. G. de Faget, of l'Office National d'Etudes et de Recherchez Aeronautiques.

All of the reports are now on file at the University of Michigan. Some have been translated or are being translated. Photostatic copies will be made available at cost to those requesting reports and, in some instances, the original reports can be loaned for one month. Inquiries should be directed to:

Director of Icing Research
Engineering Research Institute
University of Michigan
Ann Arbor, Michigan

"THE CONVECTION OF HEAT AT HIGH SPEEDS" (LA CONVECTION DE LA CHALEUR AUX VITESSES). Gustave Ribaud and Edmond Brun, Memorial des Sciences Physiques, L'Acadamie des Sciences de Paris. (1948)

A review of boundary layer equations and solutions, high speed convection, mass transfer - heat transfer analogy.

"SURVEY OF ICING INFORMATION" (SYNTHESE DES CONNAISSANCES SUR LE GIVRAGE). Edmond Brun, Rapport Technique No. 7, Groupement Francais Pour Le Developpment des Recherches Aeronautiques. (1934).

Formation and composition of fogs, supercooling of water, icing of aircraft, methods of protection (mechanical, electrical, thermal), component icing (antennae, wings, ailerons, instruments, engine accessories, propellers).

"INTRODUCTION TO THE STUDY OF THE MECHANICS OF SUSPENSIONS" (INTRODUCTION A l'ETUDE DE LA MECHANIQUE DES SUSPENSIONS). E. Brun, R. Caron, M. Vasseur. G.R.A. Techn. Rept. No. 15 (1945).

Equations of motion, similitude conditions, graphical calculation methods, application to a right circular cylinder, experimental studies (chemical and photographic studies), forced convection in fogs.

"THE ELECTRICAL STATE IN FOGS AND THE ICING OF AIRCRAFT" (ETAT ELECTRIQUE DES NUAGES AT GIVRAGE DES AVIONS). E.Brun, L Demon, G. Fasso, M. Pauthenier.

"CONSIDERATIONS OF THE REQUIREMENTS FOR A TUNNEL TO SIMULATE ICING CONDITIONS" (CONSIDERATIONS SUR LA REALIZATION D'UNE SOUFFLERIE DE GIVRAGE ARTIFICIEL). E.Brun, Jour.des Recherches, Nos. 4-5.

Discussion of the design of an icing wind tunnel, nozzles, water separators, turning vane protection.

"THE MECHANICS OF SUSPENSIONS" (LA MECANIQUE DES SUSPENSIONS). E. Brun, M. Vasseur, Jour. des Recherches du Centre National de la Recherche Scientifique, No. 3 (1947).

Presentation of the equations of motion, the graphical method of computation, application to cylinders and spheres. (Available as University of Michigan Icing Research Center translation).

"FORCED HEAT CONVECTION AT THE SURFACE OF A BODY OF REVOLUTION" (CONVECTION FORCEE DE LA CHALEUR A LA SURFACE D'UN CORPS DE REVOLUTION). E. Brun and M. Vasseur, Comptes Rendus des Seances de l'Acadamie des Sciences, 10 November 1947.

Boundary layer equations for laminar flow applied to bodies of revolution. (3 Pages).

"EXPERIMENTAL RESEARCH CONCERNED WITH THE ICING OF AIRCRAFT" (RECHERCHES EXPERIMENTALES CONCERNANT LE GIVRAGE DES AVIONS). E. Brun. (Technical and Scientific Publications by the Secretary of State for Aviation, Bulletin of the Technical Services, National Center for Scientific Research). (1941).

Laboratory production and study of ice, effect of the formation process on the ice characteristics, structure of ice, supercooling of water, speed of crystallization, spontaneous freezing, mechanical properties of ice, measurement of temperature in an icing wind, experiments on propeller anti-icing, a study of icing of windshield in an icing wind tunnel.

"ANTI-ICING AND DE-ICING OF PLANES BY ELECTRIC HEAT" E. Brun, Revue Aeronautique Internationalle, June 1937.

This report appears to be the earliest available analysis of electrical de-icing. A practical de-icer is discussed, laboratory and wind tunnel tests are reviewed. The benefits from the heat of fusion of ice and the advantages of short bursts of high power are shown experimentally. (The report is written in both French and English).

"THE MECHANICS OF SUSPENSIONS AND ITS APPLICATION TO ICING OF AIRCRAFT" (LA MECANIQUE DES SUSPENSIONS AT SON APPLICATION AU GIVRAGE DES AVIONS), E. Brun, R. Caron, M. Vasseur; French National Congress on Aviation--Report No. 74, 10 pages,(1945).

Presentation of the graphical technique for computing water drop trajectories.

"THERMAL ANTI-ICING" (L'ANTIGIVRAGE THERMIQUE), E. Brun, R.Caron, M. Petit, G.R.A. Report No. 42, (1946).

a general analysis of different schemes for thermal anti-icing. Discussion of hot air systems using combustion heaters.

"CALCULATIONS FOR A THERMAL ANTI-ICER" (CALCUL D'UN ANTIGIVREUR THERMIQUE), E. Brun and M.Vasseur, G.R.A. Report No.49, (1946).

This report gives a detailed calculation of the energy requirements for hot air anti-icing for a specific icing condition.

"STUDY OF CONVECTION IN CLEAR AIR AND IN A FOG" (ETUDE DE LA CONVECTION DANS L'AIR CLAIR ET DANS LE BROUILLARD), E.Brun, G.R.A. Technical Note No. 9, (1943).

A detailed study of heat and mass transfer from a heated cylinder in an air stream with and without fog present.

"ANTI-ICING THROUGH THE NUCLEATION OF FOGS" (ANTI-GIVRAGE PAR CONGELATION DU NUAGE), J. Maurin, La Recherche Aeronautique O.N.E.R.A., March (1948).

A description and analysis are given of experiments in which explosive bullets set off upstream were used to cause freezing of a supercooled fog before the fog reached a model.

"THE INFLUENCE OF ULTRA SONICS ON SUPERCOOLED WATER" (INFLUENCE DES ULTRA SONS SUR L'EAU EN SURFUSION), J. Palme, G.R.A. Technical Note No. 73, (1947).

Laboratory studies are described in which test tube water samples, confined fogs and free fogs were studied in the supercooled state and in an ultrasonic field using an ultrasonic generator and Hartman type sirene.

"INFLUENCE OF ELECTRICAL PHENOMENA ON THE ICING OF AIRCRAFT" (INFLUENCE DES PHENOMENES ELECTRIQUES SUR LE GIVRAGE DES AVIONS), E. Brun and M. Pauthenier, G.R.A. Technical Note No. 37, (1946).

Laboratory experiments with various electrically charged models.

"CONDITIONS FOR SPONTANEOUS FREEZING OF SUPERCOOLED WATER" (CONDITIONS DE CESSATION SPONTANEE DE LA SURFUSION DE L'EAR), Y. Doucet (Preface by E. Brun), G.R.A. Technical Note No. 35, (1946).

Historical resume of data on supercooling, a laboratory method of measuring supercooling, new experiments and discussion of the data.

"CONTRIBUTION TO THE EXPERIMENTAL STUDY OF COMPARISONS OF ICING AND DE-ICING OF METALIC AND PLASTIC SURFACES" (CONTRIBUTION A L'ETUDE EXPERIMENTALE COMPAREE DU GIVRE AT DU DEGIVRAGE DE SURFACES EN MATIERES PLASTIQUES OU EN METAL), G. Fabre; G.R.A. Technical Note No. 52, (1946).

"ICE WARNING INDICATORS" (AVERTISSEURS DE GIVRAGE), J.Idrac; G.R.A. Technical Note No. 31, (1945).

A 53 page report reviewing types of ice warning indicators using optical, thermal, sonic, and other techniques.

"FORCED CONVECTION OF HEAT IN THE LAMINAR REGIME AT THE SURFACE OF A BODY OF REVOLUTION" (CONVECTION FORCEE DE LA CHALEUR EN REGIME LAMINAIRE, A LA SURFACE D'UN CORPS DE REVOLUTION), M. Vasseur; La Recherche Aeronautique No. 5, September-October (1948).

The method of Eckert is extended to bodies of revolution.

"THE COALESCENCE OF AEROSOLS--CONTRIBUTION TO THE STUDY OF FOGS WITH A VIEW TO THEIR DISSIPATION" (LA COALESCENCE DES AEROSOLS --CONTRIBUTION A L'ETUDE DU BROUILLARD EN VUE DE SA DISSIPATION), Jean Palme; G.R.A., Technical Report No. 16, (1945) (Preface by E. Brun).

A 102 page treatise on theoretical and experimental approaches to fog dispersion.

"ICING DETECTORS" (LES DETECTEURS DE GIVRAGE), E. Brun; G.R.A. Bulletin No. 3.

A review of different types of ice warning indicators.

"PROCEDURE FOR DETERMINING THE TRAJECTORIES OF PARTICLES IN SUSPENSION IN A FLUID" (PROCEDE POUR DETERMINER LES TRAJECTOIRES DE CORPUSCULES EN SUSPENSION DANS UN FLUIDE), E. Brun and R. Caron; G.R.A. Bulletin No. 3.

An experimental technique is demonstrated wherein fine wires are suspended across the icing tunnel. The ice grows in such a way as to show the local tangent to the trajectory. Many wires then can be used to give the direction field of the trajectories.

"OBSERVATIONS OF THE PHENOMENA OF ICING AND CONDENSATION IN THE SUPERSONIC WIND TUNNEL AT BELLEVUE" (OBSERVATIONS DE PHENOMENES DE GIVRAGE ET DE CONDENSATION DANS LA SOUFFLERIE SUPERSONIQUE DE BELLEVUE), E. Brun and Max Plan. G.R.A. Sarbonne Report 4-6-46.

A few observations are given for the icing of a small cone placed in a supersonic wind tunnel where the total temperature is above freezing but the resultant temperature at the nose of the cone permits the small drops which condense from the air to freeze upon impact.

"ON THE FORMATION OF FOGS OF SUPERCOOLED WATER AT VERY LOW TEMPERATURES" (SUR LA FORMATION DE BROUILLARDS D'EAU SURFONDUE A DE TRES BASSES TEMPERATURES), Edmond Brun and Max Plan. Comptes rendus des seances de l'Academie des Sciences, pp 351-352, 19 August 1946.

Report on the observation of fog at -100° C at the throat of a supersonic wind tunnel at total temperature 12° C, Mach Number 2. Optical measurements indicated drops were smaller than 1 micron.

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