INCLUDING SUPPLEMENTARY PAPERS



## THE AERONAUTICAL JOURNAL

**JUNE 1969** 

#### NOTICES

BRANCHES

GRADUATES' AND STUDENTS' SECTION

- A. Stratton LOOKING AHEAD IN AERONAUTICS—19: AIR TRAFFIC AND NAVIGATION IN THE SECOND CENTURY
- P. Martin IN DEFENCE OF PRIVATE, BUSINESS AND AERIAL WORK FLYING
  - AIR TRANSPORT GROUP SYMPOSIUM ON AIRPORTS AND TRANSPORT AIRCRAFT: INTER-RELATIONS AND INTER-FACE PROBLEMS

THE WOMEN'S ENGINEERING SOCIETY

TECHNICAL NOTES

Cylinder

R.	к.	Penny	The Creep	of	Pressurised	Cylindrical	Shells
----	----	-------	-----------	----	-------------	-------------	--------

- M. C. Mathur The Static Stability of a Cone-Cylinder Flare and Two Cone-Cylinder Fin-Flare Combinations at Supersonic Speed
- R. T. Griffiths and C. Y. Ma

THE LIBRARY

Reviews: The Great Air War—Aircraft Stability and Control for Pilots and Engineers—Lion in the Sky—A Bibliography of Refractory Metals—Advanced Mechanics—Aircraft '69—Analogue Computers—Review of the Soviet Space Program—The Promise of Space

Differential Boundary-Layer Separation Effects in the Flow over a Rotating

Additions to the Library. Reports

#### SUPPLEMENTARY PAPERS

THE AERODYNAMICS OF HIGH-LIFT DEVICES ON CONVENTIONAL AIRCRAFT

- **D. M. McRae** Part I. General Description and Comments on  $C_{\rm L\,max}$  and Stalling Behaviour
- D. N. Foster Part II. Some Aspects of the RAE High-Lift Research Programme
- H. W. Pout THE EVOLUTION OF GUIDED WEAPONS

27s 6d

### THE ROYAL AERONAUTICAL SOCIETY 4 HAMILTON PLACE LONDON W1

## Decca/Omnitrac-pictorial navigation in three dimensions

Only Decca/Omnitrac provides accurate three dimensional navigation. The system incorporates a closed-loop servo-driven display head providing a track trace on conventional charts and is the first system to offer vertical guidance readout.

#### **Closed** loop

Digital servos continuously compare navaid position co-ordinates with corresponding outputs from the computer/display system, not only eliminating the need for manual chart setting, but ensuring complete integrity since the display will reset and update itself, automatically, without error, even after interruption in the drive to the display head. Ordinary, or 'open loop' displays can, without warning to the pilot give false position indication, arising from malfunction due, for example, to increased friction or handling.

#### **Track trace**

One glance at the track trace on the Decca display head tells the pilot not only where he is, but also where he's come from, and the rate at which he is approaching his desired track. He can thus determine navigational trends without the need to integrate successive plot indications. After use the track trace can be quickly erased or photo-printed for the record. With the Decca track trace after only one or two practice runs pilots make smooth, accurate instrument approaches to within one mile of touchdown.

#### Vertical guidance

Vertical guidance is programmed into the Omnitrac computer, for display on the Flight Director. When altitudes required at waypoints along the route are set into the computer, information is displayed in one of two ways:

EN ROUTE Commands for climb or descent are displayed until the programmed altitude is attained.

APPROACH The difference in altitude and distance between two successive waypoints is used to define a flight path or 'glide slope'. In this way multiple routes free the pilot from point to point navigation and an extremely accurate flight profile can be maintained, regardless of terrain features and weather. Only Decca has real experience with pictorial displays—over  $2\frac{1}{2}$  million flying hours by BEA alone ....

#### **DECCA** puts navigation in 3D back in the cockpit

#### The Decca Navigator Company Limited • London



THE ROYAL AERONAUTICAL SOCIETY

Incorporating The Institution of Aeronautical Engineers and The Helicopter Association of Great Britain

Telephone: 01-499 3515 Telegrams: Didaskalos, London, W1 Published Monthly at 4 HAMILTON PLACE, LONDON W1V 0BQ Subscriptions: £15 15s. 0d. per annum, post free Single Copies: 27s. 6d.

VOLUME 73	NUMBER 702	JUNE 1969
~		

69

Page

#### CONTENTS

	NOTICES	XLVII				
	BRANCHES	LIII				
	GRADUATES' AND STUDENTS' SECTION	LIV				
A. Stratton	LOOKING AHEAD IN AERONAUTICS—19: AIR TRAFFIC AND NAVIGATION IN THE SECOND CENTURY	461				
P. Martin	IN DEFENCE OF PRIVATE, BUSINESS AND AERIAL WORK FLYING	472				
	AIR TRANSPORT GROUP SYMPOSIUM ON AIRPORTS AND TRANSPORT AIRCRAFT: INTER-RELATIONS AND INTER-FACE PROBLEMS	480				
J. V. Block	International Airport Planning as Influenced by Aircraft Development					
E. J. Dickie	Progress in Air Traffic Control and its Relationship to Airport and Aircraft Development					
G. S. Hill	Economics of Air Operations as Affected by Current Transport Aircraft Design Trends					
D. R. Blundell	Airport Restrictions as they Affect Airline Planning					
E. L. Killip	Airport Problems in Flight Operations					
G. Davidson	The Airport and the Aircraft in Relation to Loading Problems					
D. Newman	Aircraft Design as Determined by Airport Facilities and the Environment					
K. S. Lawson	The Influence of the Airport, its Facilities and Environment on Aircraft Design and Operating Economics					
	THE WOMEN'S ENGINEERING SOCIETY	513				
	TECHNICAL NOTES	514				
R. K. Penny	The Creep of Pressurised Cylindrical Shells					
M. C. Mathur	The Static Stability of a Cone-Cylinder Flare and Two Cone-Cylinder Fin-Flare Combinations at Supersonic Speed					
R. T. Griffiths and C. Y. Ma	Differential Boundary-Layer Separation Effects in the Flow over a Rotating Cylinder					
	THE LIBRARY	527				
	Reviews: The Great Air War—Aircraft Stability and Control for Pilots and Engineers—Lion in the Sky—A Bibliography of Refractory Metals—Advanced Mechanics—Aircraft '69—Analogue Computers—Review of the Soviet Space Program—The Promise of Space					
	Additions to the Library. Reports					
	SUPPLEMENTARY PAPERS THE AERODYNAMICS OF HIGH-LIFT DEVICES ON CONVENTIONAL AIRCRAFT	535				
D. M. McRae	Part I. General Description and Comments on $C_{L \max}$ and Stalling Behaviour					
D. N. Foster	Part II. Some Aspects of the RAE High-Lift Research Programme					
H. W. Pout	H. W. Pout THE EVOLUTION OF GUIDED WEAPONS					
Editor: JOAN BRUCE, BSc, 6 Secretary of the Society: A.	CEng, AFRAeS.       Advertisements Only:         M. BALLANTYNE, OBE, TD, BSc,       H. E. SOUTHON.	504				
FID, CENG, HONFCASI, F	MAA, FRAED. Wagazine Advertising Ltd, 164 Fleet Street, London	, EV4.				

4 HAMILTON PLACE, LONDON, W1V 0BQ. Tel: 01-499 3515.

**Reproduction of any of the papers published in this journal is not permitted without the written consent of the Editor.** 

None of the papers or paragraphs must be taken as expressing the opinion of the Council unless otherwise stated.

PRINTED BY THE LEWES PRESS WIGHTMAN & CO. LTD., LEWES, SUSSEX, ENGLAND, AND PUBLISHED BY THE ROYAL AERONAUTICAL SOCIETY, 4 HAMILTON PLACE, LONDON, W1V OBQ, ENGLAND.

Tel: 01-242 0434/5.

#### The Royal Aeronautical Society

FOUNDED 1866

INCORPORATED BY ROYAL CHARTER 1949

Patron: HER MAJESTY THE QUEEN

#### COUNCIL

President: AIR COMMODORE F. R. BANKS, CB, OBE, CEng, CGIA, HonFAIAA, HonFRAeS, RAF(retd)

President-Elect: PROFESSOR J. A. J. BENNETT, DSc, PhD, CEng, FAIAA, HonFRAeS

Vice-Presidents:

SIR ROBERT COCKBURN, KBE, CB, PhD, MSc, CEng, FRAeS G. S. HISLOP, PhD, BSc, ARCST, CEng, FRAeS S. D. DAVIES, CBE, BSc(Eng), CEng, FRAeS

Past Presidents:

A.D. BAXTER, MEng, CEng, FRAeS SIR MORIEN MORGAN, CB, MA, CEng, FRAeS PROFESSOR D. KEITH-LUCAS, HonDSc, MA, CEng, FRAeS

Members:

ers:
CAPTAIN E. C. BEARD, CBE, FRAeS, RN(retd)
M. J. BRENNAN, BSc, CEng, FRAeS
T. T. N. COLERIDGE, BE, CEng, FRAeS (President of the New Zealand Division)
H. DAVIES, CB, MSc, CEng, FAIAA, FRAeS
G. A. FORD, CEng, AFRAeS (President of the Rhodesia Division)
H. GARDNER, HonDSc, BSc, CEng, FRAeS
W. F. HILTON, DSc, PhD, DIC, CEng, AFAIAA, FRAES
E. HUTCHINSON, BSc, GradRAeS (Chairman, Graduates' and Students' Section)
B. P. LAIGHT, MSc, CEng, FRAeS
PROFESSOR K. L. C. LEGG, BSc(Eng), BSc, CEng, FRAeS
P. G. MASEFIELD, MA, CEng, HonFAIAA, FRAES
P. G. MASEFIELD, MA, CEng, HonFAIAA, FRAES
M. N. NEAT, MA, CEng, FRAES
W. N. NEAT, MA, CEng, FRAES
D. W. NORMAN, BSc, CEng, FRAES
G. K. C. PARDOE, BSc, DLC, CEng, FRAES
G. K. C. PARDOE, BSc, DLC, CEng, FRAES
G. K. C. PARDOE, BSc, DLC, CEng, FRAES
M. ROBERTS, PhD, BSc, CEng, FRAES (Chairman, Rotorcraft Section)
AIR VICE-MARSHAL C. N. S. PRINGLE, CBE, MA, CEng, FRAES
H. ROBERTS, PhD, BSc, CEng, FRAES (President of the Southern Africa Division)
G. T. WANSBROUGH-WHITE, ARAES
K. G. WILKINSON, BSc, DIC, ACGI, CEng, FRAES
N. H. WOOD, DCAE, CEng, AFRAES
M. H. WOOD, DCAE, CEng, AFRAES
M. W. WOODS, DPhil, BE, BSc, CEng, FRAES (President of the Australian Division)

Officers:

Hon. Treasurer: C. F. HUGHESDON, AFC (Associate) Solicitor: L. A. WINGFIELD, MC, DFC (Hon Companion) Secretary: A. M. BALLANTYNE, OBE, TD, PhD, BSc, CEng, HonFCASI, FAIAA, FRAeS

Note: The President of each Division and the Chairman of each Section of the Society is a Member of Council by reason of his office.

# **Rolls-Royce** the power in the air

Aircraft powered by Rolls-Royce turbofan, turbojet, turboprop or turboshaft engines are in service with or on order for more than 180 airlines, 250 corporate operators and 60 armed forces all over the world.

Some of these aircraft are shown below.

- 1. Lockheed L.1011 TriStar—RB.211 2. Concorde—Olympus 593. 3. McDonnell Douglas Phantom—Spey
- 4. VC10—Conway. 5. Westland Sea King—Gnome 6. Hawker Siddeley Harrier V/STOL—Pegasus.



ROLLS-ROYCE LIMITED · DERBY · ENGLAND · Aero Engine Division · Bristol Engine Division · Small Engine Division

THE AERONAUTICAL JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY] 3

[ADVERTISEMENTS JUNE 1969

## We put 8 ounces of tungsten carbide in this engine

## ...without it air fares would take off too!



Inside this jet engine costly titanium compressor blades rotate at 9,000 r.p.m; rubbing against each other all the time.

Where the wear is greatest they have a coating of tungsten carbide just 0.009 inches thick. Without it they'd wear out in 40 hours. With it they last over 10,000 hours. This means an enormous saving in maintenance costs. Union Carbide apply the tungsten carbide with a special gun that heats the coat-ing particles to 6,000°F and blasts them onto the titanium at 1,700 m.p.h. But don't get the idea

tungsten carbide is the only coating we can provide. Nor that titanium is the only metal we can coat. We have a comprehensive range of wear-resistant coatings, and we apply them to almost every industrial material. What is more we can apply them with precision to the wearing areas of the component. And you have the choice of using the components as coated, or machining the coating to fine tolerances. Our Coatings Service is, in fact, as advanced as the jet age itself and further proof that Union Carbide is, indeed, the discovery company in action.



**Coatings Service** from the discovery company

#### UNION CARBIDE U.K. LIMITED COATINGS SERVICE MILLERS RD, WARWICK TEL: WARWICK 41766 & SHEPLEY ST, GLOSSOP, DERBYSHIRE TEL: GLOSSOP 4351

The term Union Carbide is a registered Trade Mark of Union Carbide Corporation.





SEA KING

## ESTABLISHING THE FUTURE



SA 330

SA.341

## Anglo-French Co-operation sets the pattern of Westland Helicopter development and production for the next decade.

The Westland WG.13, a new and advanced helicopter of all-British design, plays a significant part in the helicopter agreement under which Westland Helicopters Limited and Sud Aviation are co-operating to provide the British and French Armed Forces with general-purpose,

armed reconnaissance, anti-submarine, tactical support and light helicopters for the 1970's. The Westland contribution to the Anglo-French helicopter programme will maintain continuity between the large order for the Sea King advanced anti-submarine helicopter and Westland's future rotorcraft projects.



YEOVIL SOMERSET ENGLAND

SUBSIDIARY OF WESTLAND AIRCRAFT LIMITED

ADVERTISEMENTS JUNE 1969]

6 [THE AERONAUTICAL JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY



From Menasco Manufacturing Co to E.H., a contract to supply hydraulic components for the Lockheed TriStar.

From Handley Page Ltd to E.H., a contract for landing gear and hydraulic equipment for the Jetstream.



ELECTRO-HYDRAULICS LIMITED · WARRINGTON, LANCASHIRE · TELEPHONE: 35922 · TELEX: 62145 · GRAMS: HYDRAULICS WARRINGTON STAND NO. 7·28<sup>eme</sup> SALON INTERNATIONAL de l'AERONAUTIQUE et de l'ESPACE

THE AERONAUTICAL JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY] 7

[ADVERTISEMENTS JUNE 1969

## Every single military and civil airfield in the world is known, and targeted

## The Harrier alone is not dependent on airfields.

## Hawker Siddeley-the largest aerospace group in Europe

Richmond Road, Kingston upon Thames, Surrey, England. Tel: 01-546 7741. Cables: Hawsidair, Kingston upon Thames. Telex: 23726 Hawker Siddeley Group supplies mechanical, electrical and aerospace equipment with world-wide sales and service

ADVERTISEMENTS JUNE 1969]

8 [THE AERONAUTICAL JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY