ENGINEERING RESEARCH INSTITUTE
UNIVERSITY OF MICHIGAN
ANN ARBOR

PROGRESS REPORT NO. 1

RESEARCH DESIGN PROBLEMS RELATING TO FACILITIES FOR SIMULATING THE AERODYNAMIC EFFECTS OF ATMOSPHERIC GUSTS ON AIRCRAFT COMPONENTS

October 26, 1952, to January 26, 1953

By

A. M. KUETHE

J. D. SCHETZER

L. C. GARBY

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I. SUMMARY

During this period, the design of two gust-generating devices has been started, and necessary modifications to the small subsonic wind tunnel in which preliminary tests will be made are under way. A literature search is in progress and consideration is being given to the development of analytical methods and instrumentation for evaluating the effectiveness of the gust-generating devices. In the following paragraphs a brief description is given of what has been done and the direction in which the development is progressing.

II. LITERATURE SURVEY

The main objective of the literature survey is to establish what is required of a gust-simulating device, and what experimental facilities exist that satisfy these requirements. Essentially, the problem of gust simulation is one of providing, in a wind tunnel, an unsteady flow to which a model will respond in the same manner that the prototype airplane responds to atmospheric turbulence. In addition to existing gust-simulating facilities, the literature survey will be concerned with information pertaining to the nature of atmospheric gusts, nonstationary aerodynamics, and the dynamic response of aircraft to unsteady inputs. All the information is needed in order to determine the magnitude and character of the unsteadiness that must be produced in the wind tunnel in order to obtain significant responses of the model. No attempt is being made to obtain an exhaustive bibliography. The aim is to summarize

briefly other work that bears on this project and compile a representative list of references. The survey is underway.

III. METHODS OF GENERATING GUSTS

The gust-generating device must produce a repeatable unsteadiness of such a character that the significant effects of the unsteadiness on a model can be measured. This means that the gust generator and the instrumentation must act rapidly enough to expose the fundamental nature of the aerodynamic time lags involved.

The devices being considered produce an angle of attack variation that progresses over the chord of the model. Though this feature is not essential to the study of the lags produced by unsteadiness, it does simulate actual flight through a gust. The following three basic methods of producing unsteadiness will be investigated.

A. The generating of a disturbance within the flow which will travel with the flow. The case considered is that of generating a vortex in the stream ahead of the model and allowing the vortex to pass by the model. It is planned to produce this vortex by placing a "lattice" of full spanning airfoils in the stream and actuating them in the following manner: Initially the airfoils will be at zero degrees. By the simultaneous deflection of all of the airfoils to a given angle and their immediate return to neutral, vortices will be introduced into the stream. These vortices will then travel with the flow and simulate the gust (see Fig. 1).

B. The deflection or motion of the channel wall boundaries can be used to produce a gust. For this method it is planned to build a bump which can be moved along one of the tunnel walls; it will be located downstream of the model being tested. To create the gust effect the bump will be accelerated to a given speed in the downstream direction, and then decelerated. During this period of body motion the model will experience a gust. Figure 2 is a general schematic diagram of this system.

C. The introduction of a source and/or sink into the flow may also be used to produce a gust.

All other variations considered to date appear to be combinations or modifications of the above three methods.

IV. EXPERIMENTAL PROGRESS

The basic programs by which the three methods of gust generation, vortex, bump, and source or sink, are to be investigated are as follows:

1. The moving bump will be tested first, because of its simpler design and fabrication problems.

2. The vortex-generating system will follow the moving bump in the test program.

3. The source-sink method will be the last of the three methods to be studied.

Preliminary work will be conducted in a subsonic wind tunnel located on the fourth floor of the East Engineering Building. The tunnel has been modified in order to fit into this test program and now has the following characteristics:

Type:	single-return
Test-section dimensions:	height - 21 inches
	width - 30 inches
	length - 105 inches
Maximum wind speed:	75 fps
Contraction Ratio:	4.3:1

One special feature incorporated in the modification is that the test sections are removable. This is being done in order to allow the modification of one type of gust-generating device to be made while testing is being conducted on another.

Design of the bump system has been largely completed and is in fabrication. A sketch of the system is presented as Fig. 2. Computations are being made in order to determine optimum bump sizes; however, this work is not complete at this time. It is planned to accelerate and move the bump by using aircraft shock chord as a spring. If this system does not give sufficiently repeatable results, a more elaborate system using a fixed drive will probably be used.

Design of the vortex generator is underway. Mechanical problems have been encountered due to the short cycle period required; however, it is believed that a solution is near.

As yet, no work has been done on the third method of gust generation, the use of a source or sink. This work will follow after the above two methods have progressed further.

V. INSTRUMENTATION

Two independent methods will be used in order to evaluate the gust effect:

1. a direct measurement of the flow direction by means of the hot-wire annemometer, and

2. measurement of the lift effect of the gust on an airfoil by means of a sensitive balance system.

An analytical investigation is being made of the instrumentation problem. The required sensitivity and accuracy of measurement are being studied. Various types of balance systems are being investigated, and as yet no conclusions have been reached.

VI. WORK PLANNED FOR FOLLOWING PERIOD

In the next period it is expected that the following work will be underway or accomplished:

1. The literature survey will be completed.

2. The moving-bump system will be fabricated and tested. The theoretical analysis will be completed.

3. The design of the vortex generated will be completed and fabrication started.

4. Design of the source-sink type of gust generator will be started.

FIG. 1

VORTEX GUST GENERATOR SYSTEM

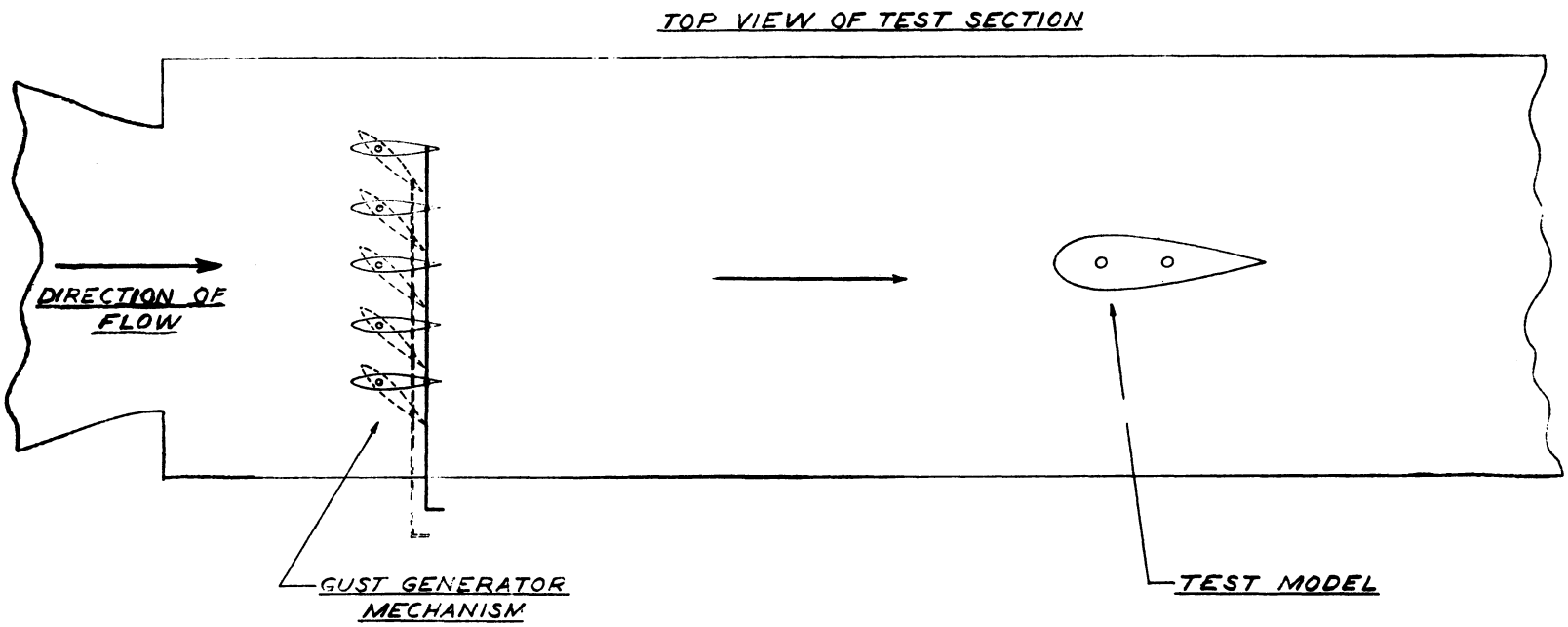
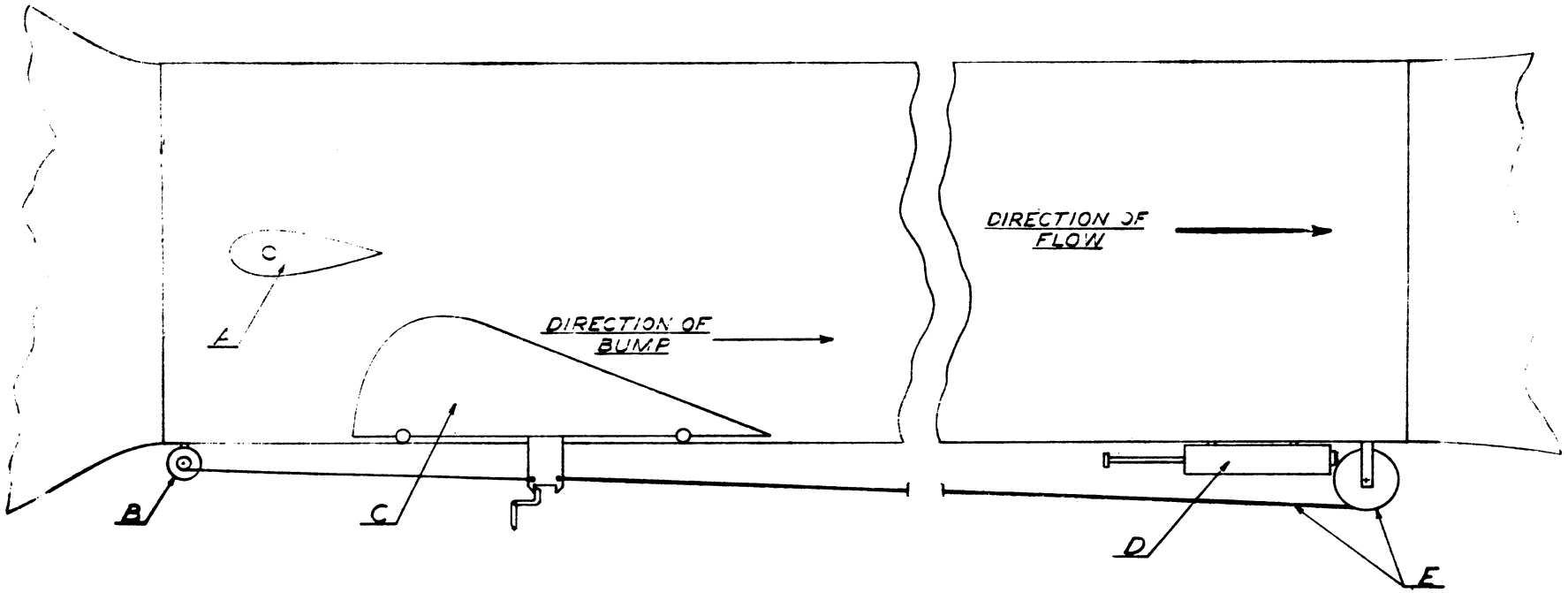


FIG. 2

MOVING BUMP GUST GENERATOR



A. TEST MODEL.
B. POTENTIOMETER TO DETERMINE POSITION OF BUMP.
C. MOVING BUMP.
D. SHOCK ABSORBING CYLINDER.
E. ACCELERATING MECHANISM (AIRCRAFT SHOCK CORD & WINDING DRUM).