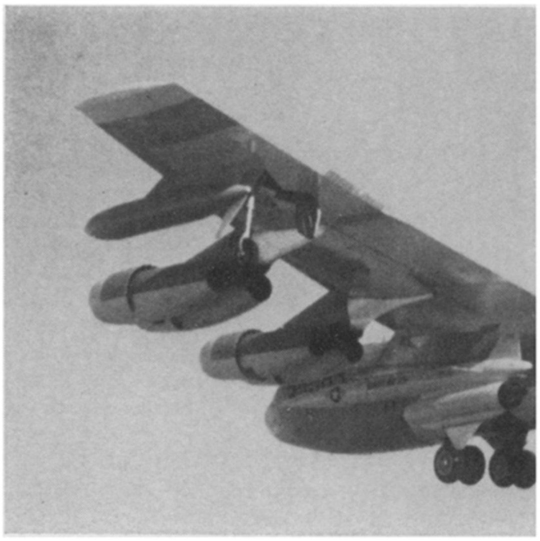
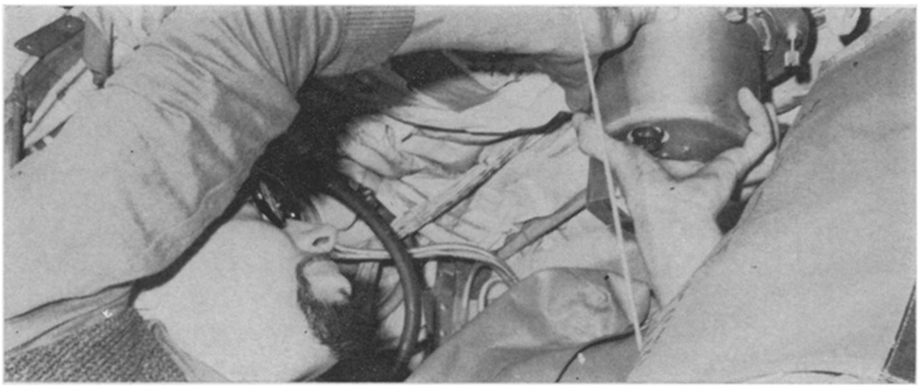


Mobilizing a search for invisible signs in the sky

Four Federal agencies are joining forces to develop a system that will detect clear air turbulence



Barnes Engineering

Technician installing radiometer sensing head in a life-raft compartment.

by Edward Gross

Clear air turbulence is the name given the violent air pockets that lurk in an apparently clear and untroubled sky. Most commonly associated with the jet stream, these whirling eddies of air have been known to rip off wing and tail sections of aircraft, injure passengers and stewardesses and seriously disorient pilots. They are all but invisible to existing detection techniques.

Clear air turbulence was implicated in 11 civilian aircraft crashes last year. Two of them were fatal. As a consequence of increasing concern for a hazard that grows with the speed, height and volume of air travel, the Department of Commerce has joined forces with the Departments of Defense and Transportation and the National Aeronautics and Space Administration in a concerted, five-year search for technology to solve the problem.

The primary goal will be to develop an airborne instrument that will warn a pilot of clear air turbulence in time for him to avoid it or at least prepare for the jolt. The basis for such a device rests on the fact that CAT produces measurable physical changes in atmospheric properties such as temperature, the index of refraction and both the velocity and direction of the wind.

Of the existing methods, the field has been narrowed to six: radar, microwave radiometry, spectrometry, laser ranging, crossed-beam detection and acoustic sounding.

The hope is that either through their modification or by the generation of new techniques from them, a reliable CAT detector can be developed. Of the six, only laser, microwave and spectrometric techniques are airborne at present. The others are ground-based.

Radar appears to have the inside track at the moment. Says one Air Force scientist, "The best thing would be to put radar in a plane, but we don't know how to miniaturize it yet and still get the power."

But ordinary radar will not do the job. Narrow-beam, ultrasensitive radar must be used to measure the degree of variation of indices of refraction in the atmosphere.

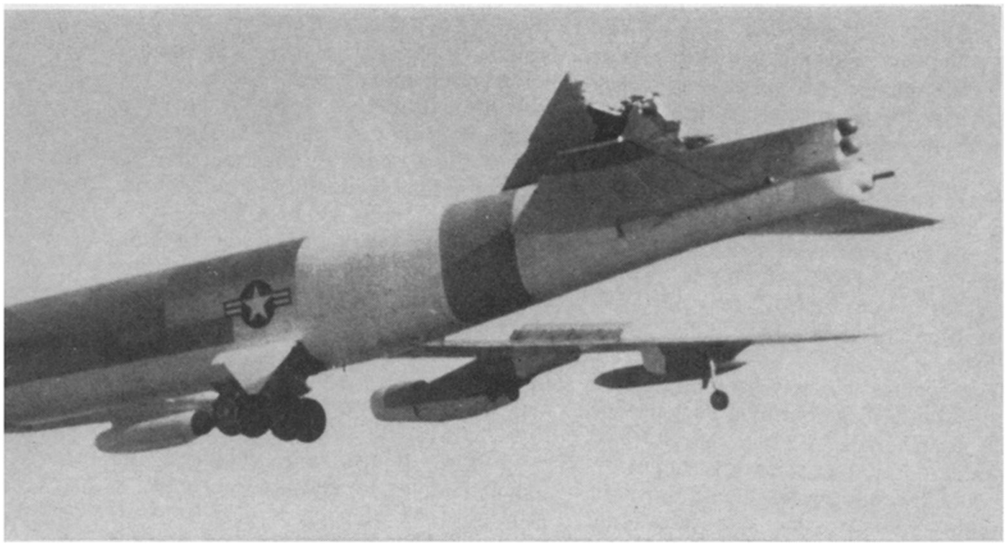
Radar has been successfully used from the ground, but as an alternative to an airborne system, it would require a costly nationwide network.

The microwave radiometer is a temperature-sensing device that works by measuring thermal differences inside the turbulent air. The temperature breakdown, or gradient, within a turbulent system progresses from areas of greater wind intensity outward to areas of lesser intensity, somewhat like waves breaking on a shore.

Although the microwave radiometer can measure the gradient and thus get a temperature profile of the turbulence, its range is limited to 10 miles or so, increasingly inadequate as the speed of jets increases. Radiometers must also be kept level. Otherwise they pick up temperatures at other levels.

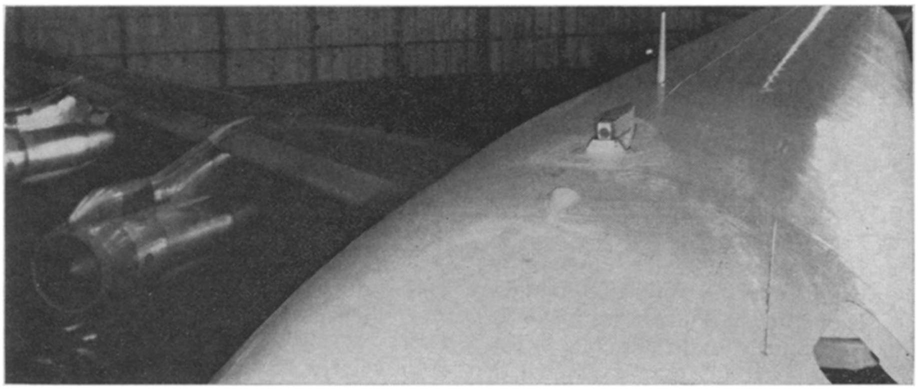
The spectrometry technique is in essence also a temperature-measuring method, but it is sensitive to infrared radiation instead of microwaves. It is subject to the same difficulties as the microwave radiometer.

The laser technique works by measuring the agitation of dust particles in the air. A pulsed laser beam is reflected by them, and their relative velocities determine the intensity of the backscatter. The greater the velocities, the more intense the backscatter, which could serve to indicate turbulence. The laser, too, suffers from a limited range problem. Despite this drawback, work is going ahead on it anyway. A pulsed



U.S. Air Force

Loss of the tail section of this B-52 was attributed to clear air turbulence.



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A sensing head for a clear air turbulence radiometer mounted on a fuselage.

carbon dioxide laser is being developed at the Marshall Space Flight Center, Huntsville, Ala., and it will be tested within a few months.

Another light technique is the crossed-beam method. Here two telescopes, angling toward each other from the aircraft, gather light from two different levels in the air. Air velocity is measured by the time it takes changes in such things as cloud movement or refractivity to show up from one telescope to another. An abrupt change could indicate clear air turbulence.

The crossed-beam method is limited by the airplane's motion, which would tend to prevent meaningful measurements, and it is already being downgraded. "For this reason, I'm not interested in it as an airborne system to detect turbulence ahead of the plane," says William McGowan, aerospace technologist at NASA headquarters.

The last technique, acoustic sounding, involves simple analysis of the backscatter produced by a noise-generating antenna. The sound reflected by a turbulent area would differ from the echo of nonturbulent air. The obstacle here is the size of the antenna required.

One Air Force investigator sums up the techniques by saying, "We can't see any yet that have proved themselves. Until some are tried and adequately tested, it's too soon to tell which one will work."

The next step that would follow the development of an adequate detector would be a national forecasting facility to predict CAT in the same way that the Weather Bureau predicts thunderstorms, snow or cold waves. To some degree, forecasting has been done, but inadequately.

"The Environmental Science Services Administration and the Air Force are actually putting out CAT forecasts now, based primarily on where intense gradients of temperature and wind are shown," says Dr. Clayton Jensen, head of the Federal plans and coordination division of ESSA's environmental systems division. "Balloon radiosondes gather data on temperature, humidity and pressure; the data are put into a set of numerical equations, and a computer generates the CAT forecast."

The limitation is primarily the area now covered. "It's too large," says Dr. Jensen. "We want to narrow it down to pinpoint the location of CAT as is done with a thunderstorm." □