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Gust Tunnel

By Steiner and Coleman

Operating problems are those problems which arise when an airplane is used day in and day out to perform some mission such as transporting bombs, passengers, or cargo. As distinct from aerodynamic questions which involve increasing the speed of the airplanes, stability, and design problems, operating problems depend on how the airplane is used and handled. Work is under way at the NACA Laboratories on numerous operating problems. Some of these problems are noise, icing, landing conditions, and gust load experience.

Some operating problems require a minute to minute knowledge of airplane operations and therefore require that special instruments be installed in transport airplanes in regular service. One instrument which has been in use for a number of years on the airlines in gust research is the V-G recorder with which many of you are familiar. A sample record from this instrument is shown in the upper portion of the first chart. This record is an envelope of maximum positive and negative normal acceleration increments or loads against airspeed. The V-G record gives pertinent information on the large gust loads which might damage the aircraft from the application of a single load, but tells nothing of the events leading up to the load experienced or tells little concerning the numerous smaller loads, obscured by the larger loads,

which contribute to structural fatigue and passenger discomfort.

As additional questions on operating problems arose it was apparent that more detailed information was required than that given by the V-G recorder. Special effort was, therefore, given to the development of an instrument of the time history type with a long recording time. This newer instrument is the VGH recorder. This instrument gives a time history of airspeed, normal acceleration and altitude.

As you can see, it is a compact instrument with a remote recording accelerometer. The instrument operates from the airplane's power supply and is turned on with the master switch of the airplane. It records photographically on a 200 foot roll of paper and a total of 90 to 100 hours of record time is available without reloading the instrument.

At the bottom of the chart is an illustration of approximately 10 minutes of a typical VGH record. The traces are shown here the same as they appear on the record. The lower trace, which is altitude, has a zero near the top of the record and increasing altitude is shown as a deflection downward. This record indicates therefore that the airplane was starting a descent from about 20,000 feet. The upper trace is airspeed, and on this record the airspeed varied between 250 and 300 miles per hour. The middle trace is normal acceleration. The peaks are gust accelerations and for the rough air encountered, the maximum acceleration increments

were about ±0.5g. These peaks go to make up the envelope obtained on the V-G record.

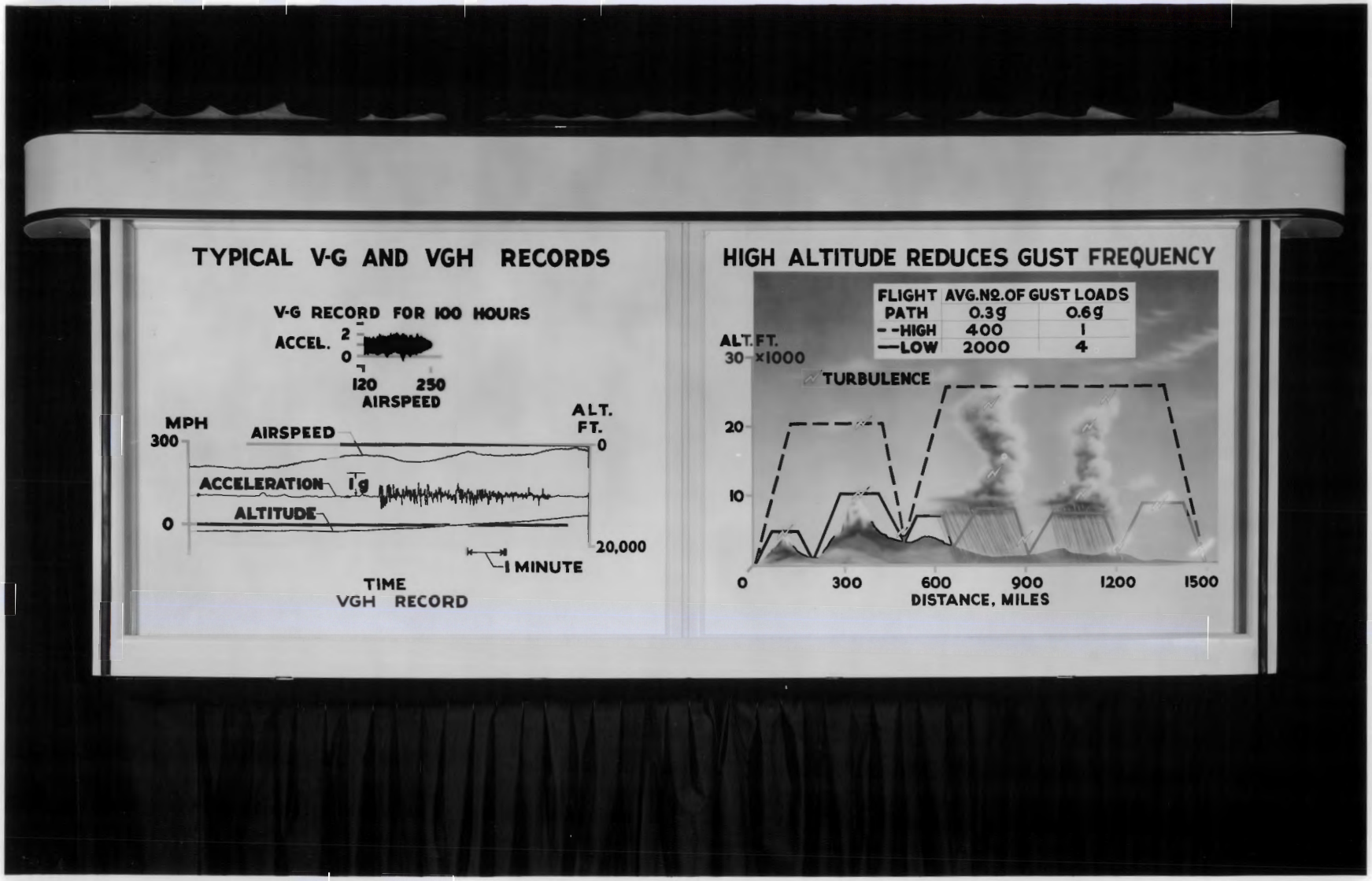
As an example of how we use the information obtained from these records some data obtained to date have been analyzed with respect to the problem of turbulence encountered by aircraft. In the study of turbulence we need information on the intensity and frequency of turbulence, and how and where the airplane is operated in turbulent air. Weather conditions which may exist along a route from the Midwest to the West Coast and some terrain features which might lead to the rough air experience of airplanes at high and low altitudes are given in the next chart. Low altitude operations are defined here as operations below 10,000 feet and high altitude operations as those from 20,000 to 30,000 feet. This mark resembling lightning is actually a symbol for turbulence. The flight paths in the chart show that an airplane which operates at low altitudes would be expected to encounter turbulence associated with mountainous regions, turbulence during landing and takeoff, and in flight through cumulus clouds or thunderstorms which could not be avoided. In contrast, the high altitude airplane could fly above many of the cumulus clouds, stand a better chance of avoiding thunderstorms, but may encounter some clear air turbulence at the high altitudes.

The average number of gusts, encountered on the low and high altitude flights of 1500 miles, is given in the table. Gusts causing acceleration increments of 0.3 and 0.6g were arbitrarily selected for comparing the gust experience on the basis that these values correspond to slight and to moderate passenger discomfort. We see that 2000 accelerations of 0.3g would be expected for the low altitude trip, but only 400 or 1/5 as many, on the high altitude flight. A similar reduction in the number of the large accelerations is also indicated in the table with 4 accelerations for the low altitude operations and one for the high altitude operations. These preliminary results indicate that an appreciable reduction in the frequency of gust loads will be obtained by operating at high altitudes.

This chart was an illustration of one turbulence investigation. While the VGH recorder was originally designed for the investigations of turbulence, the continuous records are useful in the investigation of many other problems. These problems vary from the study of airspeeds and Mach numbers to the determination of the relative lift of the wings at the time of touchdown.

At the present time we have only a few of the VGH recorders installed on commercial aircraft but have obtained the cooperation of several airlines for the installation of additional instruments.

Another operating problem, that of aircraft noise will now be discussed by .



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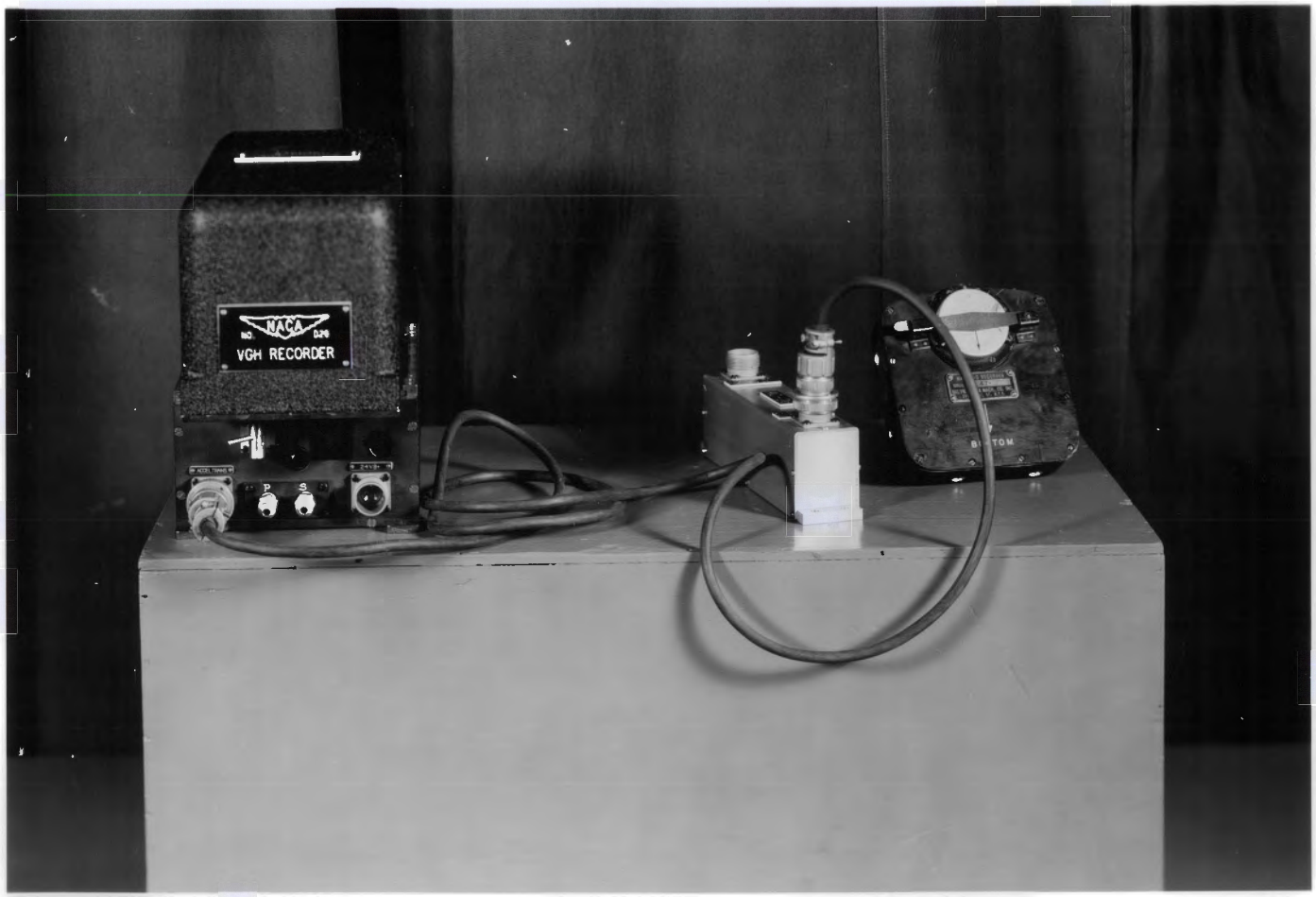

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