Attached are some answers to questions you submitted to me with your letter of December 20, 1966. Many of the statements would be difficult to document at this time. For this reason, I suppose some judgement should be exercised as to how this information is used.

In general, I have no objection to your using the material in any manner you deem appropriate in connection with the preparation of the Langley history.
NACA:

HISTORICAL COMMENTS

OF

RICHARD V. RHODE

JANUARY 23, 1967
1. Q. What, generally, was the sequence of events which led to the development of the VG and the VGH recorders?

A. The need for obtaining measurements of gust load factors on airplanes in actual service operations was recognized by NACA during the late 1920's. The earliest of measurements were made with a modified version of a commercially available instrument known as a Tetco TIM recorder. I believe the initials TIM stood for Time in Motion, because the instrument was normally used on vehicles such as trucks to record the periods during which the truck was idle or operating. A stylus, which reacted to vibrations or jarring of the vehicle, impressed a record of its motions on a circular waxed paper disc, which had a 24-hour time scale on it. The NACA converted this instrument to an accelerometer of suitable sensitivity, and, when properly installed near the center of gravity of an airplane, the instrument would register accelerations of the machine normal to the plane of the wings. It was calibrated to read acceleration in g units.

Although the converted Tetco TIM Recorder served to give some idea of the accelerations or load factors during service operations, it was not very accurate and data on acceleration alone were not enough to describe the structural loading situations
of importance. Measurements of airspeed were also required. In maneuvering flight, for example, a given acceleration occurring at low speed is associated with moderate or high angle of attack of the wing, whereas the same acceleration occurring at high speed is associated with a low angle of attack of the wing. Since the pressure or load distribution on the wing is normally greatly affected by angle of attack, it was of great importance that airspeed and acceleration be simultaneously measured to permit interpretation of the records in terms of angle of attack or load distribution.

The importance of this aspect of aircraft structural loading was greatly illuminated as a result of analyses of acceleration and airspeed records taken by the NACA on an open time scale during dive tests of the U.S. Navy's first dive bomber, the XBM-1, a biplane built by the Glenn L. Martin Company in Baltimore. In analyzing the records from these tests, Mr. Eugene E. Lundquist plotted the data on a chart in which the scale of ordinates was acceleration normal to the wing chord and the scale of abscissas was indicated airspeed. Parabolic lines, each representing a condition of constant lift coefficient (or pressure distribution) could be drawn in on this chart. With such a chart, the loading situation could be seen at a glance.
Because of these qualities, the chart became of great importance as a means of representing the critical or design loading conditions for aircraft both civil and military airworthiness requirements.

In this same time period, it became evident from studies of gust loading on aircraft that simultaneous values of normal acceleration and indicated airspeed measured in flight could be converted to "effective gust velocities" when certain simple characteristics of the airplane were known and applied to the derivation. Such effective gust velocities could, within limits, be used to determine the loads on other airplanes having different characteristics and flying at other speeds than the one on which the measurements were made. There were, however, no instruments available at that time which could be used in service operations to measure simultaneous values of acceleration and airspeed. The NACA recording accelerometers and airspeed meters, which were commonly used in flight tests at the Langley Laboratory, employed optical systems and light beams to trace their records on photographic film. They were delicate instruments and required constant maintenance and frequent re-calibration. Moreover, the operating time period for one loading of the film drums was in all cases much too short for use in service operations. All in all, it was not practicable to employ instruments of this type, even
if modified to permit long-period use, in service operations. The thought of collecting and analyzing "miles of records" in order to determine the critical loading conditions that occurred only rarely in service also acted as a strong deterrent to the development of an airspeed-acceleration recorder that would register against time with an open time scale.

The unique instrumentation requirements of the gust load problem, viz., (a) the determination of simultaneous values of airspeed and acceleration in rough air for conversion to "effective gust velocities;" (b) the necessity for measurements over long periods of time on many airplanes in service operations; and (c) the requirement for simple and rugged instrument characteristics, when considered in the light of the Lundquist acceleration-airspeed chart, led me to suggest that a simple instrument, which would register acceleration against airspeed, be devised for use in determining the desired gust-load measurements.

H.J.E. Reid, Engineer-in-Charge of the Langley Laboratory, and a skilled instrument designer and technician, undertook to devise the required instrument which he designed to employ a thin, flexible steel stylus to scratch a record on a small smoked-glass plate. The light pressure of the stylus against the smoked glass resulted in sufficiently low friction to reduce error to
acceptable small limits. The original instrument has been modified to improve the damping means and the balancing of the linkages, but today's version is still the same size and shape as the original and employs the same basic principle. Mr. Reid and I jointly held the patent on this instrument.

The instrument was given the name VG recorder for brevity and euphony at my suggestion. "V" is the standard symbol for airspeed and "G" is the capitalized version of the standard symbol, g, for the acceleration of gravity.

The Lundquist acceleration-airspeed chart was, for the same reasons, called the VG diagram, although it later became more properly known as the V-n diagram, because "n" is the symbol for normal load factor.

Although the VG Recorder filled the great need for a simple practical instrument to measure critical loading conditions in aircraft operations, it was not capable of providing much-desired detail respecting aircraft operating and loading conditions. A practical instrument capable of measuring the three quantities acceleration, airspeed, and altitude against time on a reasonably open time scale for long periods was still much to be desired.
At a later period, Mr. Philip Donely, who was then Chief of the Gust Loads Branch of the Aircraft Loads Division, pushed for perfection of an optical system and other qualities which would make the desired instrument practical and, working with Mr. Edmond Buckley (now AA/Tracking and Data Acquisition) and others of the Langley Instrument Research Division, finally succeeded in developing the fine instrument now known as the NASA VGH Recorder.

Both the VGH Recorder and the VG Recorder continue to be used as complementary devices for the measurement of aircraft load statistics.

2. Q. How did relations of the laboratory personnel with the people of Hampton change over the years? Why?

A. The laboratory personnel at Langley have always consisted in part of local people and in part of outsiders. In general, the professional employees have come from outside the community and I assume the question relates primarily to these persons and to the people of Hampton who were not employed or who had no friends or relations employed at the Laboratory.

There is no question in my mind that, in the earlier years of the NACA, the professional employees of the Langley Laboratory were, on the whole, not warmly welcomed into the community.
This fact, I believe, was owing only in part to the natural reluctance of the local people, who had had Hampton to themselves for so many years, to accept strangers into their social and civic circles; I believe it was also in part a consequence of the misguided and somewhat "smart-alecky" behavior of some of the Langley professionals, who regarded themselves as intellectually superior to the natives.

There were, of course, friendly relations established in individual cases even in the beginning. In general, however, it simply took time for the Laboratory and local people to get to know each other through church and other social and business contacts. Important factors in the continually improving relationship over the years have been the marriage of local girls to Langley professional male employees, selfless participation of Langley employees in civic and other local activities for the good of the community, and the increasing economic importance of the Laboratory to the community as the Laboratory grew in size.

A few aberrations occurred in this steadily improving picture. For example, an attempt by a prominent Laboratory employee to influence local politics was greatly resented by some of the local people and resulted in considerable trouble to NACA officials both at Langley and in Washington. Another aberration was caused by the general exemption from military service
of Langley professional employees during WW II. This situation was greatly resented by some of the local people. In some instances, employees' children were ostracized by the local children because the Langley fathers were regarded as draft dodgers.

Such instances were, however, the exceptions, and the general picture is one of cool initial reception of the NACA outsiders followed by a steady improvement in relationship over the years to a position of complete acceptance and integration into the community.

3. Q. What attractions did government work, in general, and Langley employment in particular, offer to a young graduate aeronautical engineer? Was the pay better than in industry at the time? The research facilities? The atmosphere for productive achievement?

A. I cannot answer the first or second parts of this question except in relation to my own experience. The big attraction in my case was that employment at Langley afforded an opportunity to learn something about aeronautical engineering (I was a graduate mechanical engineer) while at the same time receiving a reasonable salary. I had thought that something like two or three years of post-graduate experience at Langley would fit me for
a job in the airplane industry, where I could later get into airplane design. My work at Langley, however, proved sufficiently interesting and challenging that the urge to leave for a job in industry became greatly weakened. This change in attitude was related to the situation that developed in the airplane business shortly after the Lindbergh flight, which occurred less than two years after I entered on duty at Langley. The Lindbergh flight resulted in great interest in aviation and a number of new small airplane companies were started. A considerable demand for aeronautical engineers developed and many of the Langley engineers were attracted by the new, better-paying jobs. The resignations of several engineers of the old Flight Research Section, which was under John W. Crowley, quickly improved my rank in the section and, in particular, made me fall heir to the PW-9 flight loads project, which was then in its planning stage.

My initial salary as a "Junior Aeronautical Engineer" was $1,860.00 per year, or $155.00 per month. During interviews with various company representatives, when I was a senior at the University of Wisconsin, salary offers for 4-year graduate mechanical engineers ranged generally from $100.00 to $125.00 per month. I found that my government salary was sufficient to permit me, as an unmarried young man, to live on half of it
and to bank the other half, although this ratio changed radically when I bought my first automobile and again when I got married!

The research facilities at Langley and the atmosphere for productive achievement in the early days were closely related. The professional employees were regarded by Washington and Langley authorities as the key to NACA's success, and they were encouraged in every way to create new and better research facilities. It is, I think, important to note that the facilities were not something created or designed by a separate group of people for use by the Langley professional employees. The NACA became famous as an outstanding aeronautical research establishment because of the opportunities the professional employees were given to innovate, both in their research projects and in the development of new facilities.

4. Q. What, in your opinion, were the most significant technical accomplishments of the Langley Laboratory - LaRC originated or LaRC contributions to improvement of already existing airplanes?

A. No time period has been stipulated in this question. The contributions over the years have been well documented and publicized and I have nothing to add.
5. Q. From your experience, what were the relations like with 1) the military? 2) industry? 3) Congress? 4) NACA Headquarters? 5) universities?

A. 1) Relations with the military during the early years of NACA were excellent. The military needed the results of NASA research and NACA engineers were anxious to please. As time went on, however, and the military sought to conduct its own research through a system similar to that now employed by NASA in its contract research programs, the early close and friendly relationships deteriorated to a degree. This difficulty, which existed primarily between Langley professionals and some of the military and civilian personnel at Wright Field, occurred partly because of the creation by the military of a competitive aeronautical research activity, but more particularly (at the working level) because the military research project people had more money to spend than they know how to spend wisely. I well remember the resentments caused at Langley when the military sought to pick the brains of the Langley engineers and scientists for ideas that could be used as a basis for contract research projects to be sponsored by the military. We wanted an opportunity to do our own research work - not to hand out ideas to others so that they could have all the fun and get all the credit. Notwithstanding such difficulties, the relationships with the military have, over the years, been good.
2) Relations with industry were also, on the whole, very good. We used to think of an aeronautical team consisting of three elements: the NACA, which produced the new research results to make advances in aeronautical technology possible; industry, which had the ability to utilize the research results in the design and production of new airplanes; and the military, which was the principal user and whose requirements for continually improved airplane performance constituted the challenge to NACA and the industry. I believe that the military and industry generally thought in similar terms, and that there was a spirit of mutual respect and confidence. Again, specific aberrations in this picture could be mentioned, but, in all instances that occur, they were related to the idiosyncrasies of individuals or to temporary pressures on individual organizational elements within NACA, the military, or industry.

3) Relations with Congress were much less formal, and hence, much closer, than they are now. NACA officials used to go fishing and play poker with influential members of the Congressional appropriations committees! This kind of relationship resulted in far better understanding, but not in any derogation of integrity on either side.

4) Langley officials and key professional people had great love and respect for such men as Dr. Joseph S. Ames, the chairman
of NACA for many years; Dr. George W. Lewis, the Director; and Mr. John F. Victory, the Executive Secretary. These men visited Langley frequently and regularly, and Dr. Lewis got to know most of the Langley people on a first-name and almost personal basis. On their part, the Headquarters officials displayed confidence in the Langley people, but would not hesitate to apply a firm hand when necessary.

5) Most relationships between Langley and the universities were at an individual and professional level. Universities conducted a limited amount of aeronautical research in connection with their teaching responsibilities, but there were nothing like the large Government-supported grants and contracts programs that exist today. The individual relationships were, so far as I know, entirely satisfactory, as they were based on personal friendships and mutual professional respect.

6. Q. How much was economy stressed in laboratory work during the depression?

A. There was a definitely felt, but perhaps not too severe, pinch at the working level, both in salaries, which were reduced ten percent with no promotions permitted for several years, and in the wherewithal to conduct research. There was no profligate spending to begin with, and much work was accomplished with
equipment made from Army and Navy surplus material "scrounged" from Langley Field Army units and from the Norfolk Navy Yard and Naval Air Station. There is a story told about an encounter that Dr. Joseph S. Ames had with the Chairman of the Appropriations Committee (of the House, I believe) when the depression was at a very low point. The Committee Chairman remarked, in effect, "We all know that programs of government agencies contain items of relatively small importance, and I'm sure you realize the importance of reducing our expenditures to a bare minimum. Now what, Dr. Ames, can you eliminate from the NACA budget request to reduce your program to its bare essentials?"

Dr. Ames promptly replied, "Nothing! This program is already down to its bare essentials. Your problem, Mr. Chairman, is to decide whether to eliminate the NACA entirely or to keep it in business at the requested level!" NACA got its appropriation.

7. Q. What was it that made the Langley Laboratory the success it became?

A. I believe this question is answered in the last paragraph of my response to question 3 and to part 4) of question 5.

8. Q. What was your role, if any, in the establishment of the new NACA laboratories in 1939 and 1940?
A. As Chief of the Aircraft Loads Division, I was responsible for establishing the requirements for laboratory facilities needed in loads research. In the West Area, these facilities included a loads research laboratory and office building (which has since been converted to the NASA Administration Building); the Loads Calibration Laboratory (later used for fatigue research, storage, and office space); the Gust Tunnel (now offices); and the Impact Basin (also now offices). I recall that the first of these facilities was built during the 1939-40 time period with John Garvin of the Aircraft Loads Division assigned as project officer to look after the Division interests. I am not sure of the construction dates of the other facilities.

9. Q. What problems and methods were involved in the Lockheed Electra fix-up?

A. This is a difficult question to answer briefly, because the problems covered political and economic as well as complex technical considerations. One of the most difficult problems was to decide, at an early stage of the situation, whether or not to ground the airplanes. If they were grounded, there was no question but that several airlines and the Lockheed Aircraft Corporation would suffer tremendous financial loss, if not complete ruin. Furthermore, the nation's air transport system

* Langley Headquarters
would be severely crippled for a long, indefinite period. On the other hand, if they were not grounded and further accidents occurred, there would be terrible loss of life and great political repercussions. As one of General "Pete" Quesada's principal technical advisors (on loan from NASA at his request), I feel that I was largely responsible for his decision to permit the airplanes to continue to fly under suitable operating restrictions.

The technical aspects of this situation were extremely complex and possible causes considered related to various loads and structures problems under dynamic conditions, including landing impact, flight in turbulent air, and wing and tail flutter; the elevator control system was also extensively re-examined. Although I have never read the report of the CAB and am not sure what their findings were, there is no question but that the preponderant view of NASA, FAA, and Lockheed engineers was that the primary cause of the flight failures was a flutter phenomenon called "Propeller whirl," in which a wobbling motion of the outboard propellers coupled with a fluttering motion of the wing. This phenomenon was the subject of extensive tests on a 12-ft. span dynamically-scaled model of the Electra in the NASA Transonic Dynamics Tunnel (formerly the 19-ft. Pressure Tunnel) at Langley.
One of the best and most accurate general accounts of the Electra situation that I know of appeared in an issue of Life Magazine during the month of July, 1960. I would refer you to this article for further more detailed information in a compact package.