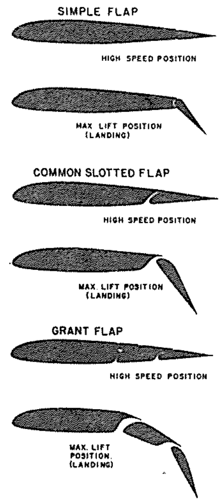
CHARLES HAMPSON GRANT



The Early Bird Everyone Knows

By JAMES J. SLOAN

This is in reality Part Two of the story of Charles Hampson Grant. The late Willis L. Nye, a longtime friend and associate of Grant, had written the first part for the Journal in early 1970 and upon his death in June 1971 the early history of C.H. Grant as Willis knew him was edited and printed in the JOURNAL, Fall 1971. It concluded with how the International Gas Model Airplane Association was accepted by the National Aeronautic Association as the nucleus for the founding of the present Academy of Model Aeronautics, now a world-wide organization with *American Modeller* as its "house organ." The IGMAA had been founded by Grant and carried on for years under his leadership through the magazine *Model Airplane News.* Willis forwarded a considerable quantity of letters and documents supplied by Grant concerning his work in the field of model airplane stability and full-scale airplane design to this editor. Together with these and much correspondence with Charles H. Grant over the past fifteen months, the following account has been written.

The remarkable career of Charles H. Grant is actually three careers in one, overlapping of course, but quite separate in their execution and in their impact on young men, the publishing world, and the world of technical aircraft design. Grant had founded his summer camps for boys in the early 1920's, and it was extremely successful – in only recent months Grant was still receiving letters from men who fifty years ago, had attended camp under Grant's direction and had been profoundly influenced by the experience.[1]

Grant also had, as a result of his work on model aircraft, become the editor of *Model Airplane News* in 1932 and in the eleven years thereafter he brought the magazine to a position of world eminence among the youth from 7 to 70 years of age. He wrote the basic textbook on model aerodynamics, *Model Airplane Design and Theory of Flight,* published in 1941, later through the 4th Edition, and which is most notable for the demonstration of what Grant called "The Law of Rotational Stability."[2]

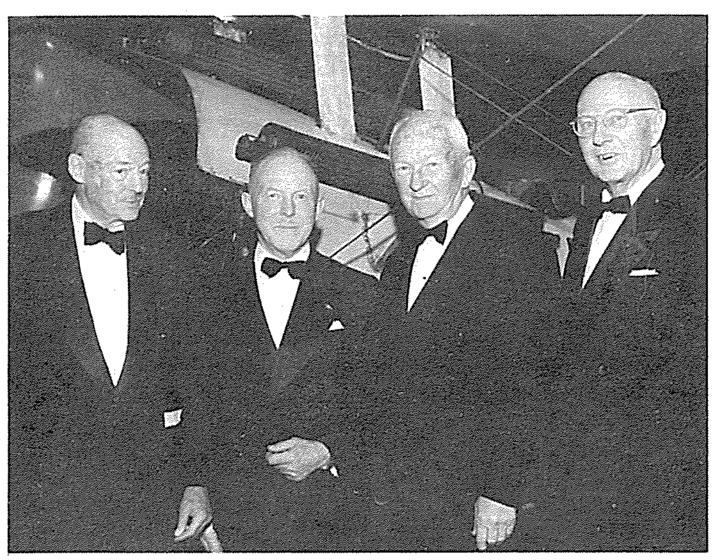
Overlying both of these careers, however, was his inventiveness in aircraft design spanning from his first hang glider in 1909 to the present day, for he is even now engaged in a lightweight glider/airplane with very low landing speed and high safety, to be marketed as a kit. Safety is a word to be always stressed in connection with Grant's career; it is the philosophy prompting his evolution of the stable model airplane, of the Grant landing flap, of the Vertaplane, and of his latest designs. He has felt that safety of passengers far outweighed all other characteristics but, he admits and deplores, safety has been overshadowed by the desire for speed in passenger transport evolution.

Grant obtained, in the course of more than fifty years, a number of patents, some of which were commercially valuable for short periods of time, but one major patent was valuable in the extreme. Realization of reward for this was thwarted by what could be laid to "the system." Four of his patents were for model airplane designs, and as was related by Nye, very successful businesses were started on them.[3] Two more evolved from needs of the model airplane field, the helical propeller cutting device and a model motor winder.[4] His first full scale aircraft patent was for a low-drag wing radiator, suggested while designing for Col Virginius Clark during WWI. The patent application was filed in November 1921 and the patent conveyed in 1925.[5]

The concept of the drooping leading-edge and trailing-edge applied to the Dayton-Wright RB-1 Racer, ingenious as they were, was not patented. At least not in the form applied to the Racer. Howard Rinehart, who was to fly the Racer in France for the Gordon Bennett Trophy, had enlisted the aid of Grant in design of the wing, the objective being to have a small wing with high lift for takeoff and landing. Though the Racer was unsuccessful Grant pursued his work in high-lift devices. He used model airplanes because of the lack of convenient test facilities and wind tunnels.

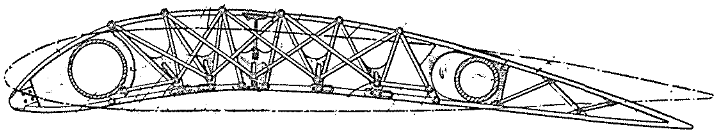
In the next twelve years Grant applied nearly every conceivable method of varying the shape of an airfoil to a model, as well as the use of movable segments, nose flaps, trailing-edge flaps, wings with and without slots, and leading and trailing-edge rotors of various configurations. The major objective was to increase and control the velocity of air over and under the wing surface on models of many sizes and shapes. It was also during the same period in which, after completing the Dayton-Wright RB-1 wing design, he started a commercial business in flying models, founded and operated "Camp Duncan Grant" in Peru, Vermont (known also as "The Boy's Camp of Model Airplane Building and Designing"), went on to another manufacturing venture in flying scale models, and then to the editorship of *Model Airplane News.*[6]

Records were kept for each type of model showing the performance and flight characteristics. These were compared to each other as well as to values derived from airfoil shapes tested in the wind tunnel. Thus a reasonably accurate picture was obtained showing the comparative values of all devices tested. As one of the fallouts of these experiments a patent was gained for a "changeable camber wing" in which the entire airfoil, from leading to trailing edge, could be changed in flight at the discretion of the pilot.[7] In this concept, the airfoil camber operating mechanism caused the forward and rear sections of the wing to pivot about the front and rear spars. As the upper surface of the airfoil remained constant in length (chord) from leading edge to trailing

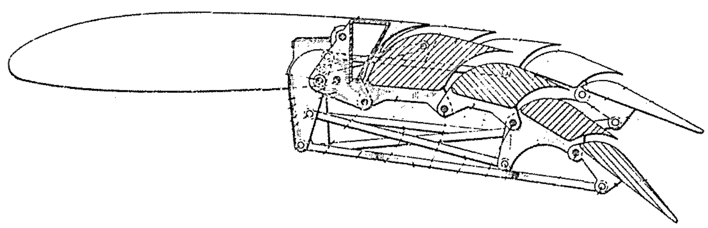


L. to r. – Jerome Clark Hunsaker, Charles Hampson Grant, Clarence Duncan Chamberlin, and Henry Roy Waite, upon the presentation of the Frank Brewer Trophy to Grant, Dec. 1968. (Camera Assoc.)

edge, the lower surface would be allowed to expand or contract. This patent was applied for in late 1933 and issued to Grant in 1935.



The state of the art of transport aircraft manufacture changed rapidly during the 1930's, with its most noticeable change being from fabric covered airfoils, wings, fuselage, or other surfaces to all-metal construction. The results of twelve years of research were evolving in Grant's mind a design which would produce the most lift with the least complication of structure, and minimal weight. It was the multiple segmented, trailing-edge flap, a design which persists to this day and for which Grant received little compensation, either in material or acclaim.[8]



Having conceived this design, Charles Grant wrote to the National Advisory Committee for Aeronautics in early 1934. NACA was then headed by Joseph S. Ames (for whom Ames Aeronautical Laboratory at Sunnyvale, Calif. was named) and had a number of very notable personnel as members, including M/Gen. Benjamin Foulois, Harry S. Guggenheim, William P. McCracken, Eugene L. Vidal, Edward P. Warner, Charles Lindbergh and Orville Wright. No more august body in the field of aeronautics existed anywhere. Grant approached the Director of Aeronautical Research, then George W. Lewis (also for whom a national aeronautical research center was named much later). He was invited to submit complete information including plans and description.[9]

The NACA, up to the year 1932, had not tested wing flaps for transport airplane use; indeed, such flaps as had been designed were mostly of the trailing-edge variety wherein the entire trailing-edge of the wing was bent downward (relative to the airstream). This increased lift in certain speed ranges, but also provided a broken airstream by allowing the boundary layer air to be disrupted. The Breguet 14 of World War One had this type of flap on its lower wing, coupled with a system of elastic shock cords which drew the flap down at low speeds but permitted it to follow the main airfoil in better streamline at higher speeds. As the pilot throttled back on landing, and his speed dropped, the flaps assisted by acting as speed brakes.

In perspective it will be remembered that the Handley Page slot, a device affixed to the leading edge of the wing to inhibit stall characteristics, had come in the mid-1920's. NACA Technical Memorandum No. 714 reported on Noda Tetsuo's variable section airfoil of the same time period, but this was not a flap. There was also the high-lift wing designed by Randolph F. Hall and placed on a novel airplane entered in the 1929 Guggenheim Safe Airplane Competition in which the flap split away from the lower surface of the wing and dropped through an arc well below the wing.[10]

In 1933 the Clark GA-43 single-engined transport airplane, designed by Virginius Clark, came into existence with perhaps the first trailing-edge split flaps. In this concept, the lower surface of the wing trailing edge was dropped down, hinged at a point in the vicinity of the rear spar, while the upper of the wing surface remained rigid. The result was a very large increase in drag and a large amount of buffeting of the tail surfaces following in the wake. The split flap was adapted to the Northrop XFT-1 and after some flight testing by Vance Breese the flap was perforated with large diameter holes which acted to reduce the buffeting effect. Northrop Gamma and Delta designs followed with the same arrangement, as did the BT-1. Very little increase in lift occured with these various types of flaps. Grant's objective was to increase lift for takeoff as well as landing, and his design, as presented to NACA in 1934, showed the entire trailing edge as being *curved* downwardly, actuated by the pilot through suitable mechanism. His concept included a means of closing the spaces between flap segments.

GRANT FLAP

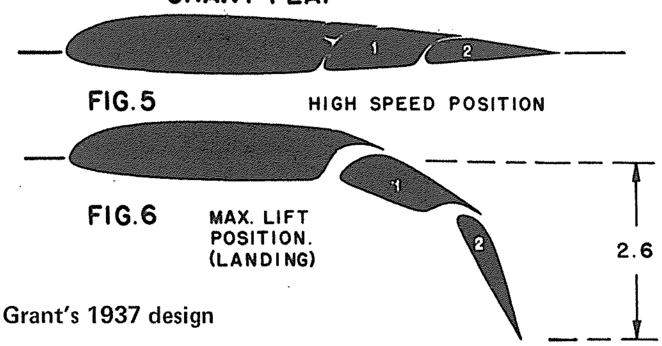


FIG.5 HIGH SPEED POSITION

FIG.6 MAX. LIFT POSITION. (LANDING)

Grant's 1937 design

Time passed, during which not much was being done to accept or reject Grant's design. In latter 1935 he heard of the procurement by NACA of a Fairchild monoplane to act as a "flight laboratory" for studying and measuring the aerodynamic characteristics of experimental wings, and he wrote that he was anxious to have his device tested in full scale flight.[11] NACA's Lewis replied the "the Committee is investigating in flight the characteristics of a number of the more promising types of high lift devices," and invited him to forward drawings again, either to the Navy Bureau of Aeronautics or to NACA.[12] This time Grant supplied a complete description, with diagrams. He pointed out that the high-lift "Grant Stream Line Flap" had a distinct advantage in that the mechanism could be constructed with slots between flap segments rather than having the spaces closed, and that this would reduce burbling and therefore increase the efficiency.[13]

In perhaps what was one of the classic blunders of bureaucracy NACA replied that, "Your proposed streamline flap was referred to the Committee's technical staff whose comments on its characteristics are enclosed."[14] It appeared plain to Grant that the technical staff did not really want to be bothered. At any rate, the comments indicated that the "technical staff" had either not done sufficient investigation or it had completely overlooked the central theme of the presentation by Grant – that his was a device that would decrease airplane speed, increase lift over the wing surface, and enhance safety characteristics by greatly lowering the stalling speed and flap drag.

Excerpts from the "comments": (Paragraph 1. described the profile drag curves for three airfoil combinations and introduced a Figure 1 showing the curves.)

> "2. It is clear from the comparison of curves 1 and 2 that the procedure of curving the rear portion of the airfoil has practically no advantage as compared with turning down the trailing-edge in the form of an ordinary flap, since it gives relatively little improvement over the split flap which has characteristics approximately equivalent to those of the plain flap. . . .(and) cannot be improved by bending the rear portion of the airfoil with more uniform curvature.
>
> "3. It is realized that Mr. Grant's device for changing the camber could be applied to such a flap but the relatively small improvement obtained in the case of unslotted flaps indicates that no large improvement could be expected when it is applied to a slotted flap. . .
>
> "4. Since available data indicate that this device is of less merit than others at present available, no tests of it are recommended.

"5. Although the weight involved in construction of the Grant type of flap might be reduced to a value nearly comparable to that of the plain flap, the mechanical complications and in particular the use of sliding elements in the mechanism appear to make the device particularly susceptible to failure through wear and jamming. . .*

"6. Although the speed range ratio of an airplane not previously equipped with flaps might be definitely improved by the installation of a smaller wing equipped with a Grant streamline flap, the improvement claimed in Mr. Grant's brochure seems scarcely credible. For example the increase of 16 percent, which he claims, could require that the drag of the complete airplane be reduced between 40 and 50 percent. Since the wing drag of a clean airplane is equal to about half its total drag, this would require that almost the total wing area be removed. . . .

That the Committee's reply was shortsighted history has proven beyond a doubt. Less than ten years later aircraft were to come into being which would use the Grant principles in utter refutation of the above "comments."

Meanwhile Grant was not satisfied with this rejection of his invention for NACA and prepared a wind tunnel model, which he promptly tested at the Danield Guggenheim School of Aeronautics under the personal responsibility of Alexander Klemin.[15] The test was made on a 6" x 36" airfoil of NACA Section 23012. Willis Nye, who had been working closely with Grant in the production of drawings for the magazine, *Model Airplane News*, submitted the results to the aeronautical engineering profession in his paper, "The Grant Streamline Flap," for which the abstract was:

"This paper describes a new type of airfoil which presents possibilities of obtaining higher lift coefficients when used with conventional airfoils. The wind tunnel investigation was performed at New York University and the results of this investigation are discussed. The results show that a substantial increment of the lift performance of conventional airfoils is possible provided the flap functions did not disrupt the boundary layer airflow. It was established that radical variations of the position of the center of pressure did not follow on the NACA 23012 airfoil which was equipped with this flap when the flap was deflected. While the movement of this flap involves mechanical linkages, little increase in the parasite resistance was found."

Willis Nye's paper was published in the *Journal of the Aeronautical Sciences* in its October 1939 issue.[16] Shortly thereafter NACA Report No. 679 was published which stated:

"The superiority of the main slotted flap with the auxiliary slotted flap for high lift with low drag, which is very important for takeoff and steep angles of the climb, is immediately evident."[17]

Its conclusion read:

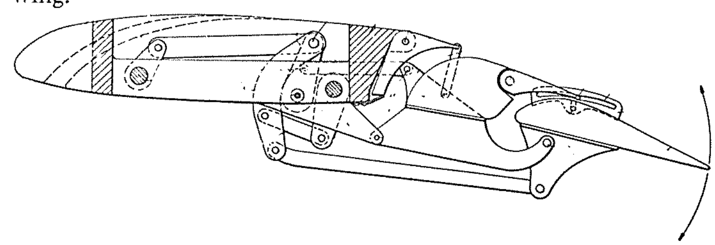
"1. The optimum arrangement of the main and the auxiliary flap combinations tested is the main slotted flap with the auxiliary slotted flap, which has more favorable characteristics than the single main slotted flap on the basis of maximum lift coefficients, and high drag at high lift coefficients."

Grant had worked out his multiple segment flap as the best combination to develop high lift for takeoff as well as for landing. Under that requirement, any such device simply had to give low drag whereas other forms of flaps were designed to give mainly a braking effect; the creation of high lift was only incidental to the main purpose. The latest Grant flap tests showed a L/D (Lift/Drag) ratio of 12.5 (where L = 2.8 and RN = 12,000,000) Compared to numerous other subsequent reports from NACA, as well as the airframe manufacturers, all showed general improvement in lift, drag and pitching moment characteristics of airfoil sections with slotted flaps.[18]

While advances in technical design proceeded at a rapid pace in the years from 1939 to 1945, safety was not paramount. The technical reports – and the engineering profession followed these with great interest – showed acceptance of the concept of multiple segmented flaps, but the requirements for such flaps on airplanes were not yet there. These requirements were to come later, after the War. But the way was clear, and in its summary report of 1948, NACA Langley stated (Jones F. Cahill - see Ref. 18) that:

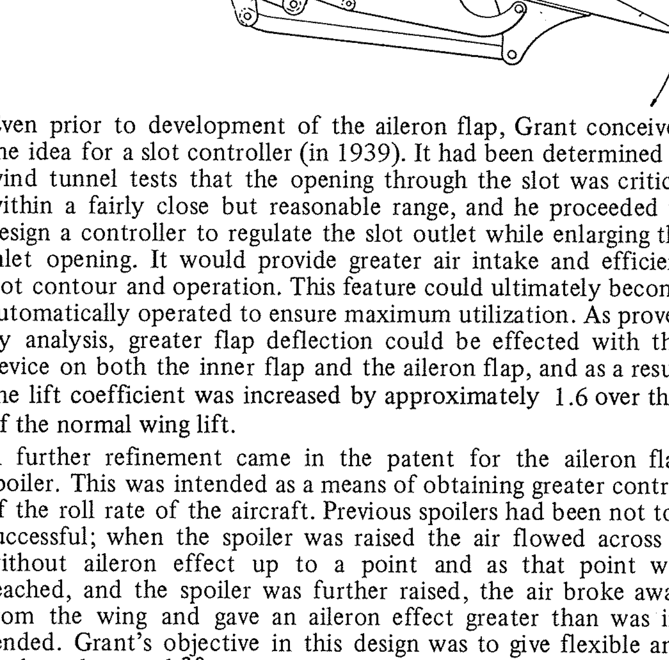
"Slotted flaps are shown to provide higher maximum lift coefficients than any other of the devices discussed."

While he was still the editor of *M.A.N.*, Grant continued with research in an effort to expand the potential use of his device. In order to provide a full span flap that would allow complete lateral control, an aileron flap was developed in 1940 with segments arranged as shown here. The second flap segment was to be dropped into the free air stream below the first segment so that large rolling moments could be obtained by aileron action, while the lift at the aileron section of the wing was increased by about 120 percent. The control mechanism was worked out, and a patent applied for in 1940, issued in 1942, described as "Aircraft Wing."[19]



Even prior to development of the aileron flap, Grant conceived the idea for a slot controller (in 1939). It had been determined in wind tunnel tests that the opening through the slot was critical within a fairly close but reasonable range, and he proceeded to design a controller to regulate the slot outlet while enlarging the inlet opening. It would provide greater air intake and efficient slot contour and operation. This feature could ultimately become automatically operated to ensure maximum utilization. As proven by analysis, greater flap deflection could be effected with this device on both the inner flap and the aileron flap, and as a result the lift coefficient was increased by approximately 1.6 over that of the normal wing lift.

A further refinement came in the patent for the aileron flap spoiler. This was intended as a means of obtaining greater control of the roll rate of the aircraft. Previous spoilers had been not too successful; when the spoiler was raised the air flowed across it without aileron effect up to a point and as that point was reached, and the spoiler was further raised, the air broke away from the wing and gave an aileron effect greater than was intended. Grant's objective in this design was to give flexible and graduated control.[20]

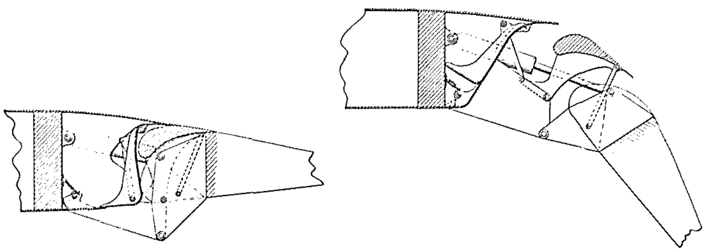


In describing his invention Grant took into consideration the fact

***Footnote: In answer to NACA's comments, Grant eliminated the sliding elements and resubmitted his more advanced flap design with two flap segments and slot controller, eliminating the sliding elements in the process. NACA went on to retest the whole concept, with totally different results, as described in its Report No. 723 of 1941.**

that, "Practical difficulties of obtaining sufficient strength and rigidity without excessive weight, in constructions that require the hinging of one or more flaps to other flaps (that are themselves hinged to the rigid portion of the wing), have discouraged the commercial use of the multiple segmented flap." One of the fallouts of this refinement was that the slot controller divided the airstream through the slot in such a way that greater deflection of the flap was possible before the air broke away from the upper surface. This is where the increased lift was effected.

His patent on the slot controller was issued in 1951.[21] (It was continuing to be more and more time-consuming between filing and issuance). Grant had submitted a complete report of both the aileron flap and the slot controller to NACA, the Inventions Board, and the War Department.



In addition to the lift coefficients, low-drag and pitch moments that were demonstrably better in the Grant Flap there were also improvements of real concern to the designer. These were: effective aspect ratio; application of the flap to the entire length of the wing including the aileron; a lower positive fuselage angle when landing; and reduced downwash of air to the tail surfaces. The problem for Grant was to get the devices into use, but preoccupation with the war and the uncertainties of postwar events were major factors. Diversification of the entire industry from a relatively few well-known company names to a widely dispersed industry with many names, served to obscure potential applications of the Grant Flap; each company would have to be sold one by one.

In 1944, Grant submitted drawings of his flap and slot controller combination with a new feature, the lower surface gate, to the Martin Company of Baltimore. The purpose of the lower gate, which was hinged at the forward edge adjacent to the main airfoil lower surface, was to rotate upward and provide a smooth wall in the slot forward of the flap.

The Martin Company accepted the device for use and it was placed on Model 2-0-2 transport, later on the Model 4-0-4. Grant filed for a patent in April 1945 and it was issued in June 1951, but not until some interesting negotiations transpired.

His experiences in the world of patented devices is not unlike that of other inventors. The adoption of his flap-with-slot-controller was discussed at all levels of the Martin Company. In a philosophic note Glenn Martin told him one day, during the negotiations, that it did not really pay to invent new commercial ideas in the aircraft industry because each would have to be turned over to the Aircraft Manufacturers Association, in accord with agreements dating back to World War One.

From another standpoint, the aircraft industry had been largely tied into government orders; many of the airframe manufacturers could not have existed without the indirect subsidy of orders for military and naval airplanes. Commercial aircraft, to which safety was more vital and the economics more uncertain, were somewhat of a side issue. Military airplanes had "operationally safe" characteristics; that is to say, safeness as applied by the pilot in the operation of his airplane but not "inherently safe," with inherent recovery stability.

As a result of his model design and experiments Grant knew that an airplane could be made inherently stable, ergo, safe. However, in the pre-WWII era of competition of the safeness of airplanes was ignored if the unsafe characteristics could be brought within the range of control by the pilot; the situation changed little in the post-War years.

Grant submitted his design for the purpose of lowering the landing speed of transport airplanes. As applied to the Martin 2-0-2 the landing speed was not lowered below what had been considered the norm – of the order of 80 to 120 m.p.h. as a range – but instead the weight went up. It increased the wing loading to about 40 pounds per square foot, and top speed was increased considerably also. Additionally, the Martin firm applied for patents on their wing flap concept after Grant had already filed (in April 1945).

Two of the Martin Company engineers, James Bennett and James Webb, sketched their flap ideas in July 1947, and filed patent applications for the double-slotted flaps on Model 4-0-4 in August 1947. The Patent Office ruled an interference between their application and that of Grant's. Invention of idea was ruled in both cases, and patents were awarded to both Martin engineers and Grant. Correspondence to Grant from the Martin Company spokesman stated, "The Patent Office interference settled that you were the first inventor and we have accepted a license under the dominating patents."[22]

COMING NEXT – The conclusion of the biography of C.H. Grant will describe the evolution of many more of his patents on segmented flaps designs and especial airfoils, the development of the delta wing, and current designs for V/STOL aircraft with greatly enhanced safety characteristics, in the Fall 1972 issue. (Ed.)

REFERENCES AND NOTES:

1. Letter, Miller Otcault to J.J. Sloan, 15 February 1972.
2. *Model Airplane Design and Theory of Flight,* New York: Air Age, Inc., 1941. (To be republished).
3. U.S. Patents 5,425 (1919); 53902 (1919); 1,313,290 (1919); 1,371,120 (1921).
4. U.S. Patents 1,333,912 (1920) and 1,370,742 (1921).
5. U.S. Patent 1,547,388 (1925).
6. See Willia L. Nye, "Charles Hampson Grant," *JOURNAL of AAHS*, Fall 1971, pp. 204-211.
7. U.S. Patent 2,022, 806, filed Dec. 9, 1933, issued Dec. 3, 1935.
8. U.S. Patent 2,146,014, filed May 6, 1936, issued Feb. 7, 1939.
9. Letter, George W. Lewis to C.H. Grant, Feb. 17, 1934 in Grant papers.
10. See Randolph F. Hall, "Cunningham-Hall Aircraft Corp. Story." *JOURNAL of AAHS*, Summer 1971.
11. Grant to Lewis, Oct. 22, 1935.
12. Lewis to Grant, Oct. 26, 1935. The R.F. Hall wing was also to be tested. See Reference [10]
13. Grant to Lewis, April 15, 1936.
14. Lewis to Grant, with enclosure, May 18, 1936.
15. *Wind Tunnel Test No. 871, Grant Airfoil With Slotted Flaps.* December 1936. Daniel Guggenheim School of Aeronautics, New York University, New York. Klemin was already well known among aeronautical circles as an outstanding engineer. He had been an instructor at M.I.T. in aeronautical engineering in 1916, was in charge of the structural test laboratory at McCook Field during WWI, a consultant to several of the aviation companies after the War, co-founded the Cox-Klemin Aircraft Corp. (producers of the TW-2), and went to New York University in 1922 as Associate Professor of Aeronautics.
16. Willis L. Nye. "The Grant Streamline Flap," *Journal of the Aeronautical Sciences*, October 1939, Vol. 6, No. 12, pages 502-504.
17. Report No. 679, "Wind Tunnel Investigation of an N.A.C.A. 23012 Airfoil With a Slotted Flap and Three Types of Auxiliary Flap," by Carl J. Wenzinger and William E. Gauvain, National Advisory Committee for Aeronautics, 1939.
18. Report No. 723, "Wind-Tunnel Investigation of NACA 23012, 23021, and 23030 Airfoils Equipped with 40-percent Chord Double Slotted Flaps," by Thomas A. Harris and Isidore G. Recant. 1941, NACA.
Report ACR 3120, "Wind-Tunnel Investigation of a Low-Drag Airfoil Section With a Double Slotted Flap" by Seymour N. Bogdonoff. 1943, NACA Langley.
Research Memorandum No. L8DO9, "Summary of Section Data on Trailing Edge High-Lift Devices," by Jones F. Cahill, Aug. 20, 1948, NACA Langley. This latter report had numerous bibliographic references which cited the above reports and many more pertaining to plain, slotted, split, Gwinn, and Fowler flaps and other variations of each.
19. U.S. Patent 2,289,704, filed Feb. 26, 1940, issued July 14, 1942.
20. U.S. Patent 2,635, 837, filed April 9, 1945, issued April 21, 1953.
21. U.S. Patent 2,556,326, filed April 9, 1945, issued June 12, 1951.
22. *Aviation Week*, May 10, 1954, page 42.