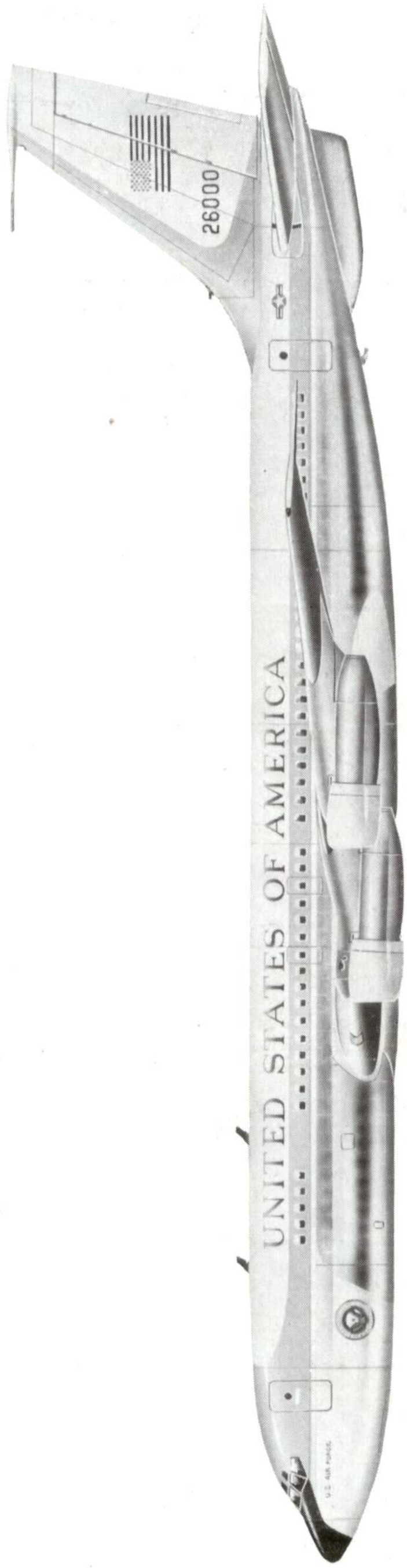
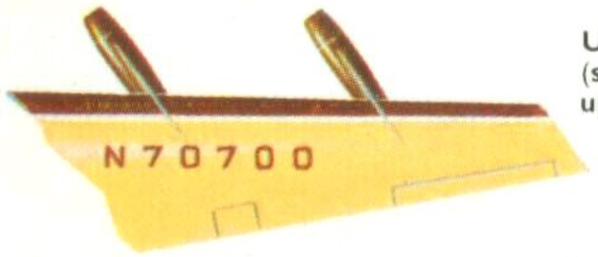
PROFILE PUBLICATIONS

The Boeing 707

NUMBER 192





Upper wing style; undersurfaces brown, with white characters **BOEING** (starboard, between engine pods) **N70700** (port, same position as starboard upper surface).

Boeing 707 prototype, Model 367-80 in original colour scheme.

P.I.A. fuselage insignia.

Boeing 707-340C, AP-AUN of Pakistan International Airways.

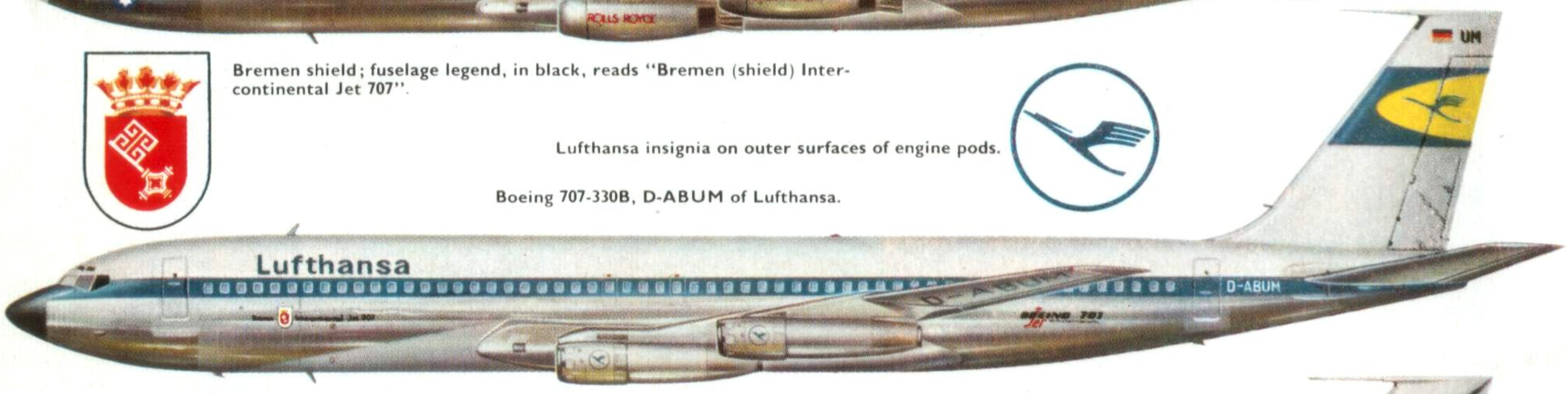
Boeing 707-349C of Flying Tiger Line.

Boeing 707-458 of El Al.

Bremen shield; fuselage legend, in black, reads "Bremen (shield) Intercontinental Jet 707".

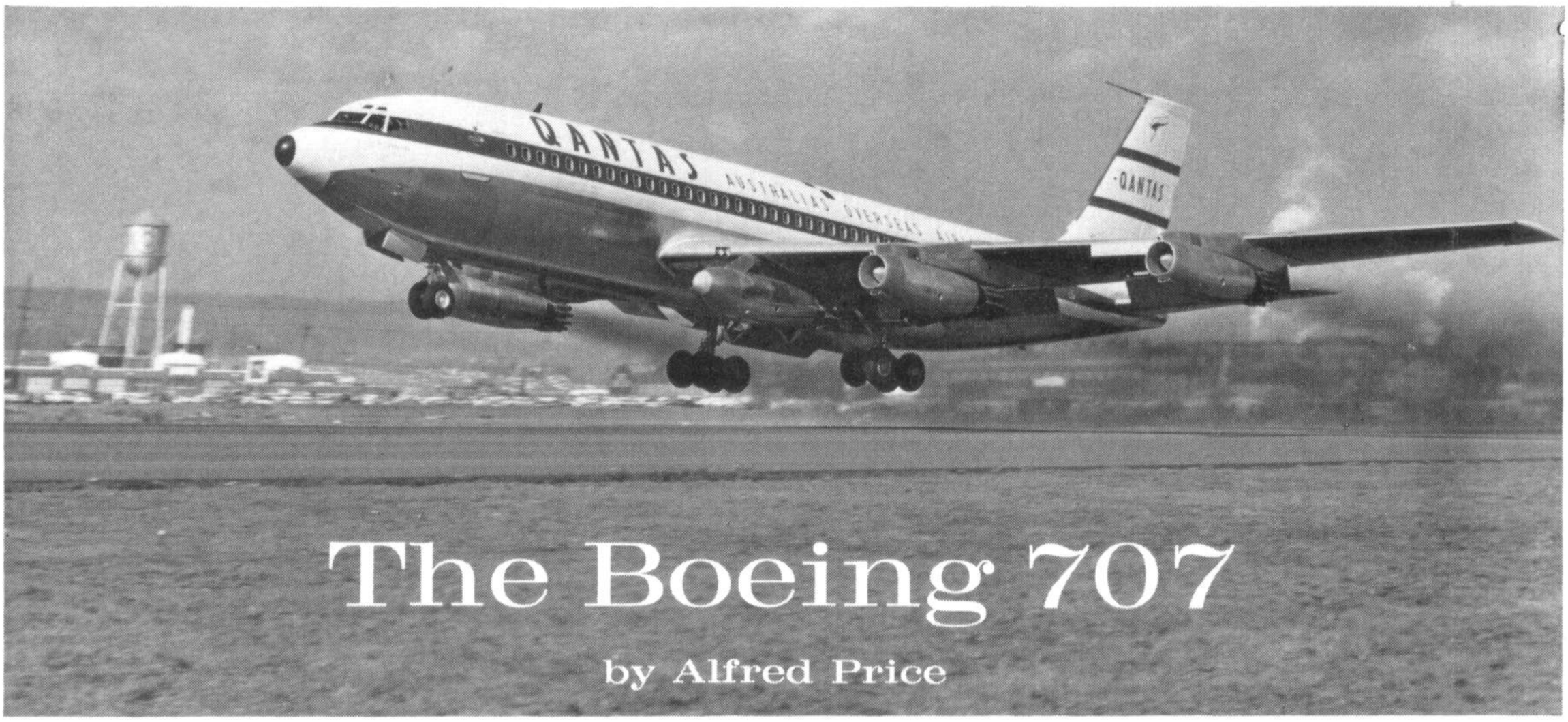
Lufthansa insignia on outer surfaces of engine pods.

Boeing 707-330B, D-ABUM of Lufthansa.



Boeing 707-328, F-BHSB "Chateau de Chambord" of Air France.

Chateau de Chambord



The Boeing 707

by Alfred Price

A 707-138 of Qantas surges into the air; this particular version had a fuselage ten feet shorter than the standard -120, to reduce weight and improve range performance for the long overseas flights made by that airline. Note the special pod, fitted when it is wished to transport an extra engine. (*Unless otherwise indicated, all photographs appearing in this* Profile *are provided by the Boeing Company*)

Today, as the air transport business moves towards the threshold of the supersonic era, it is easy to take for granted what has gone before. Yesterday's technical revolutions have become today's commonplace. The 707 was the first of the so-called "big jets" to enter service. At the time of its introduction in 1958 there were still grave doubts on the commercial feasibility of such a machine. Flying an aircraft to within a second decimal place of the speed of sound was all very well for picked service crewmen wearing the full paraphernalia for survival but how was the man, or rather the old lady, in the street going to cope? And the airline pilots—could they safely make the transition from piston engined aircraft to swept wing jets flying twice as fast? The very size of the new jets seemed to pose another problem: if there were accidents they would be big ones, involving up to 150 people each time.

Quite apart from the safety aspects, there were other worries for the airline chiefs: how was the great initial cost of the big jets—around £2 million each—ever to be recouped? If this sum were to be spread over the ten year expected life span of the aircraft it amounted to £23 per hour, for every hour of every day during that period. And that £23 per hour was just the depreciation; there still remained the direct running costs of the airliners.

The dangers to passengers of travel at near-sonic speeds proved to be illusory. Indeed, it is now accepted that the best way for old ladies to travel is in pressurised air conditioned aircraft, flying above the turbulent lower air masses. Where there were accidents they tended to be, as with other aircraft, at the beginning or the end of the flight. The problem of getting enough skilled men to pilot the big jets was tackled at both ends: the men *were* trained to cope with the new swept wing aircraft, and with modifications the jets themselves became easier to handle. And with it all, flying has become safer. From a passenger fatality rate of 1·16 per hundred million passenger miles in 1958, the last year before the jets entered large scale service, the fatality rate had fallen to 0·62 in 1964.

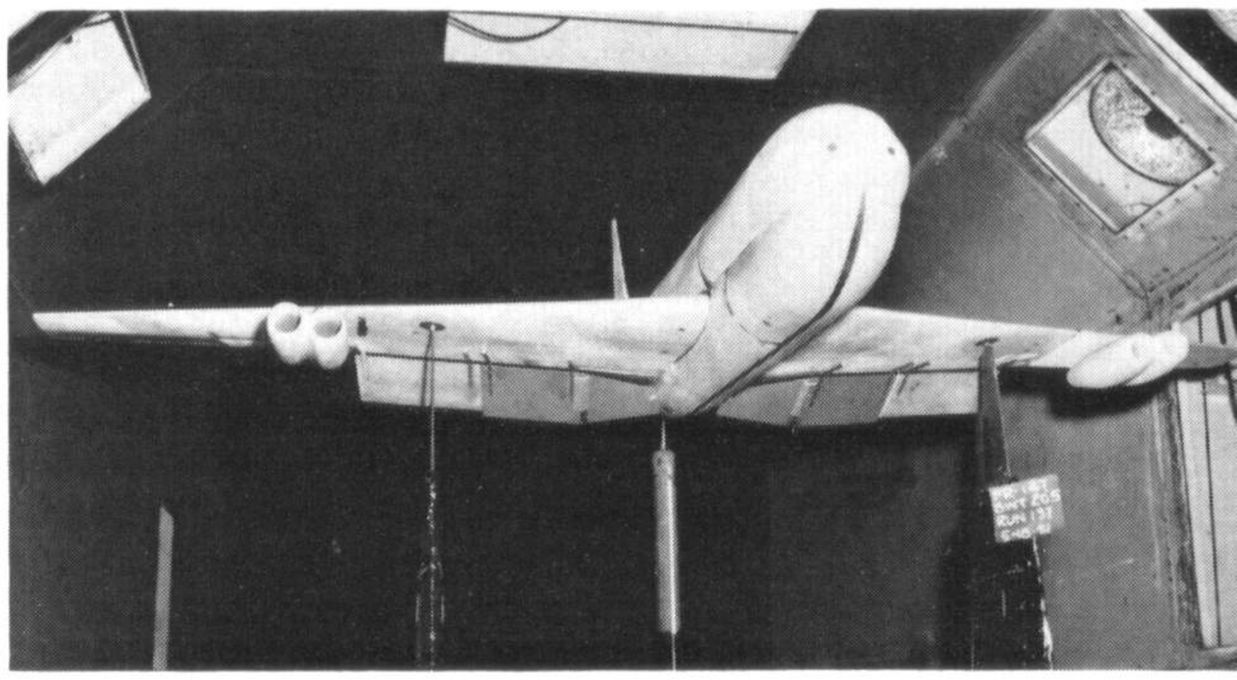
The problem of offsetting the high initial cost was answered in the most obvious way: the big jets would have to be kept in the air, earning money. And they were. During the year 1964-65 B.O.A.C. (one of the most efficient operators) got an average of 3,752 hours out of each Boeing 707 in their fleet. That meant an *average* of more than ten hours flying time per day, for every day of the year. And if costs were higher, so was productivity; the 707 is able to do four times the work, measured in seat-miles per flying hour, than aircraft in the D-C-7/L.1649 era could. So travel costs tended to fall as demand rose.

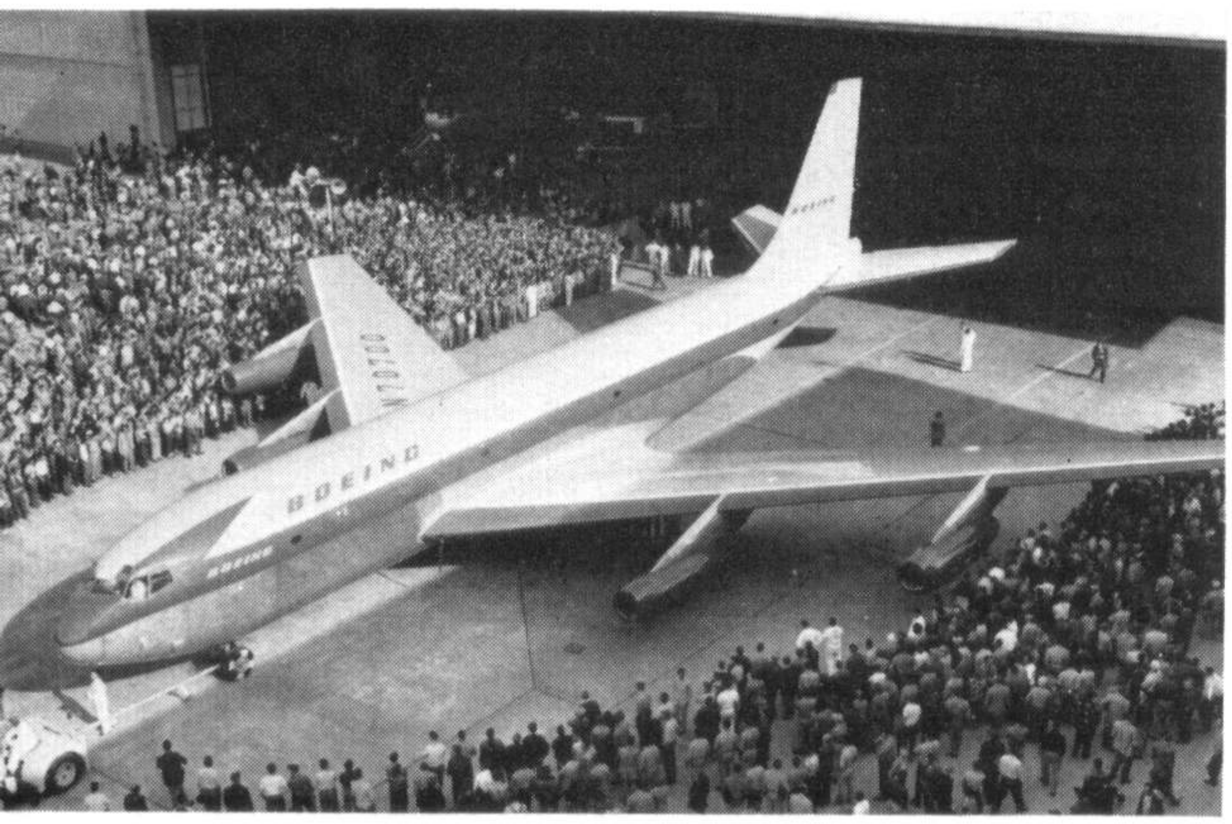
It was these economic factors more than any other—and that includes passenger appeal—which brought about a revolution in air transport: the transition almost overnight, from the piston to the jet airliner.

THE EVOLUTION OF THE 707

The Boeing company began feasibility studies into jet airliners as early as 1946, even while the Model 377 Stratocruiser was undergoing its service trials. Since no government funds could be obtained for such a revolutionary project these studies were confined to wind tunnel models and drawing board

Wind tunnel model of an early Boeing proposal for a jet tanker/freighter, the Model 367-64. Note the "double bubble" fuselage similar to that fitted to the C-97, and the engines mounted in pairs.





The Boeing 707 prototype, the Model 367-80 more usually called simply "Dash Eighty", during the roll out at Renton on the 15th May 1954.

With Boeing test pilot Tex Johnston at the controls, the "Dash Eighty" made its first flight on the 15th July 1954.

projects. One line of thought was an airliner based on the B-47, and during the late 1940's the company put out publicity releases with artists' impressions of machines with bicycle undercarriages and other unmistakable similarities with the B-47. However this line came to nothing.

Thought was then concentrated on a jet-powered development of the Model 367, the military C-97. Various arrangements of swept wing and tail surface were considered for the Model 367, which for a long time retained the distinctive double bubble fuselage of the original aircraft. These projects were typified by the Model 367-64, illustrated here, which was to have been powered by four Pratt and Whitney J57's paired in pods mounted under the wings at the mid-span points.

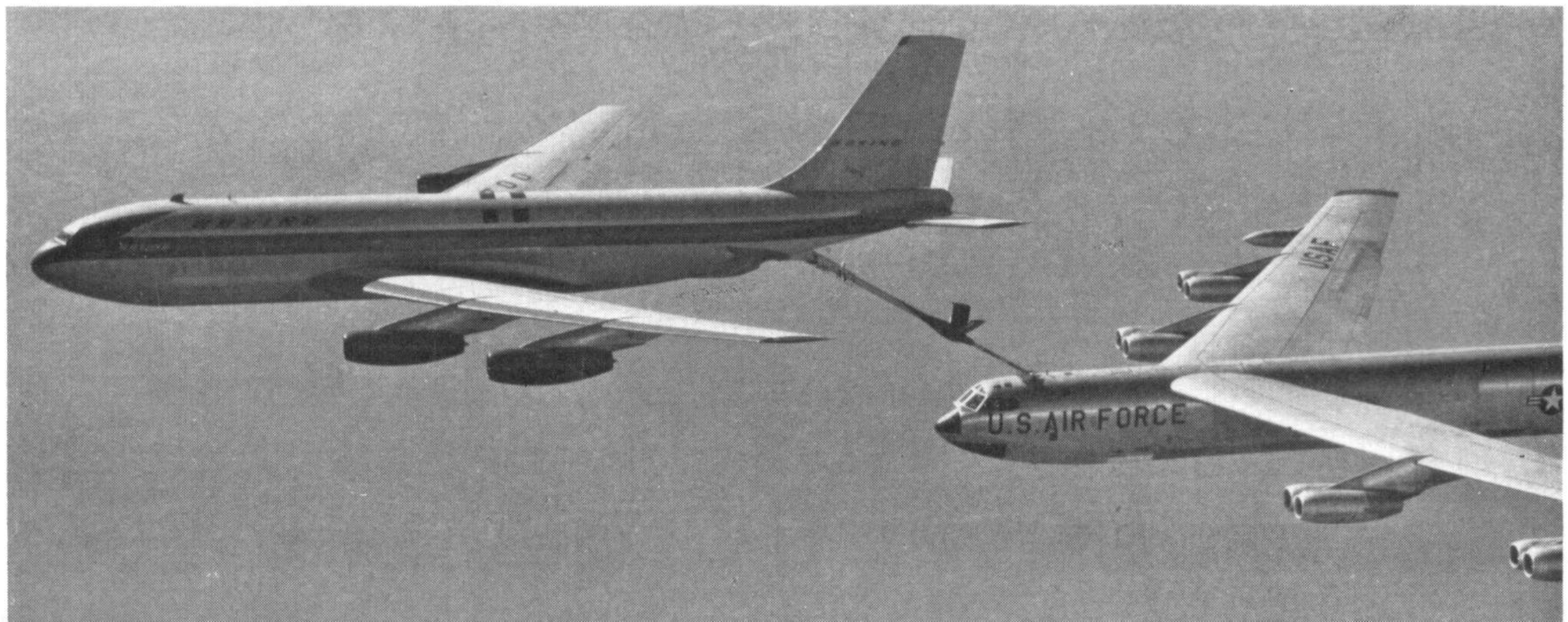
During 1951 Boeing tried hard to sell the U.S. Air Force on the idea of a fleet of jet powered "Advanced KC-97" transport/tankers to support the Strategic Air Command's B-47 strike force. Although interested, the Air Force pleaded lack of funds. However, Boeing continued with development work, and in succeeding studies the last recognisable features of the Model 367 disappeared. By the time the 367-80 was on the boards, Boeing were considering a completely new aeroplane.

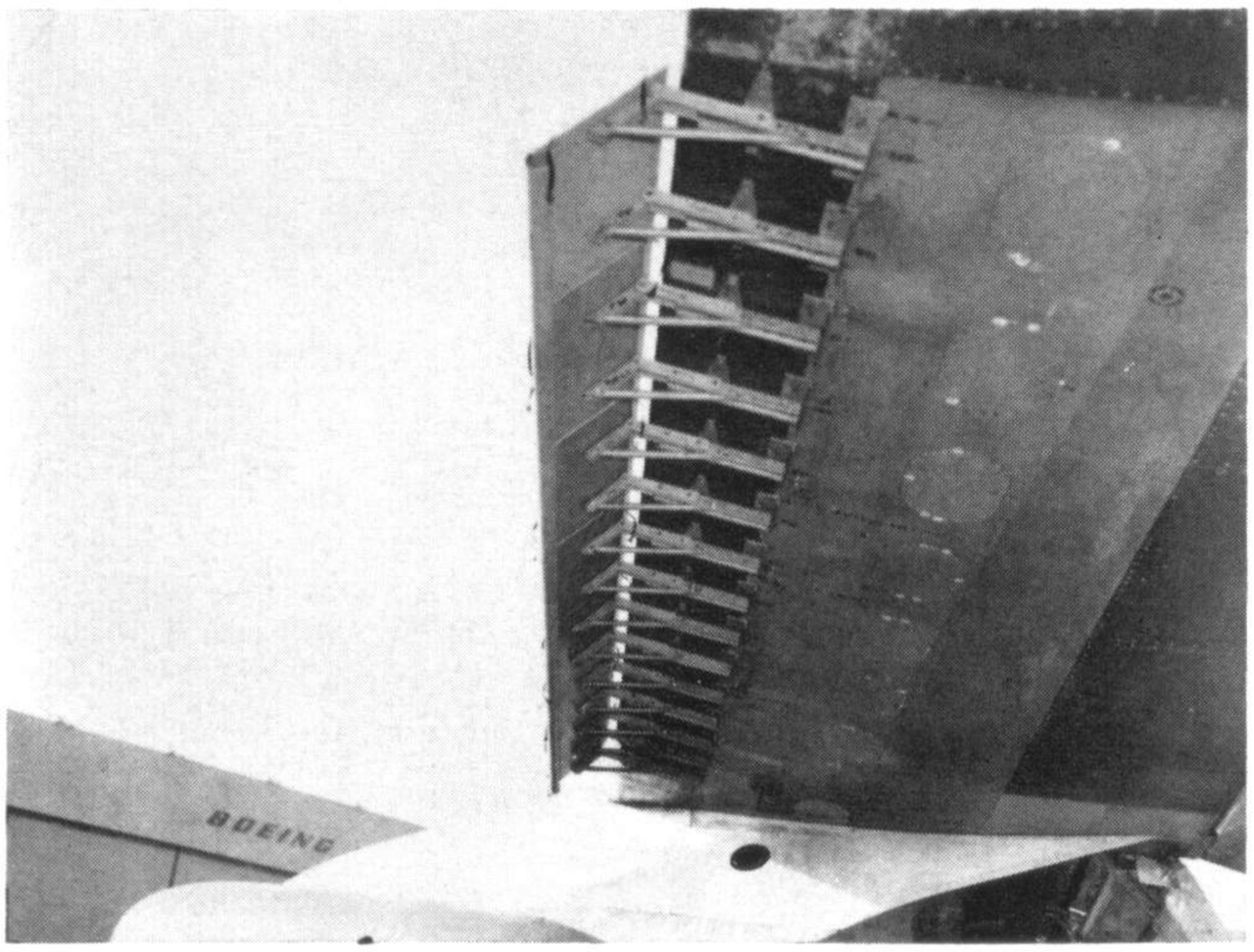
One week after the first flight of the B-52, on the 22nd April 1952, Boeings decided to press ahead with the 367-80 as a private venture. The new aircraft was to have the model number 707. Sixteen million dollars (nearly six million pounds sterling) of company money were allocated to the project. But at first the Board of Directors wished to keep the new design a secret within the company. Accordingly the project number 367-80 was retained for the prototype. As intended, this had the effect of linking the new airliner with the much older C-97. The first metal was cut in October 1952, and for the next nineteen months work continued behind closed doors.

The chocolate and yellow prototype of the new airliner was rolled out of the assembly hangar at Boeing's Renton plant on 15th May 1954. Though many continued to refer to it as the 367-80, or more simply as the "Dash Eighty", this aircraft was publicised as the Boeing Model 707; by no coincidence, it was registered N 70700. This machine was intended solely as an experimental aircraft to test the new configuration, and was never fitted out to carry passengers.

One week later, near disaster struck the gleaming prototype. Boeing chief test pilot Tex Johnston was at the controls during a taxi trial when there was some brake chatter, then the port undercarriage leg collapsed. It took six weeks to make good the damage. When Boeing engineers came to examine the undercarriage leg itself, they found a flaw in the

"Dash Eighty" fitted with the Boeing developed "Flying Boom" refuelling system. Here a B-52 is shown in one of a number of tests to prove the feasibility of the KC-135 project.





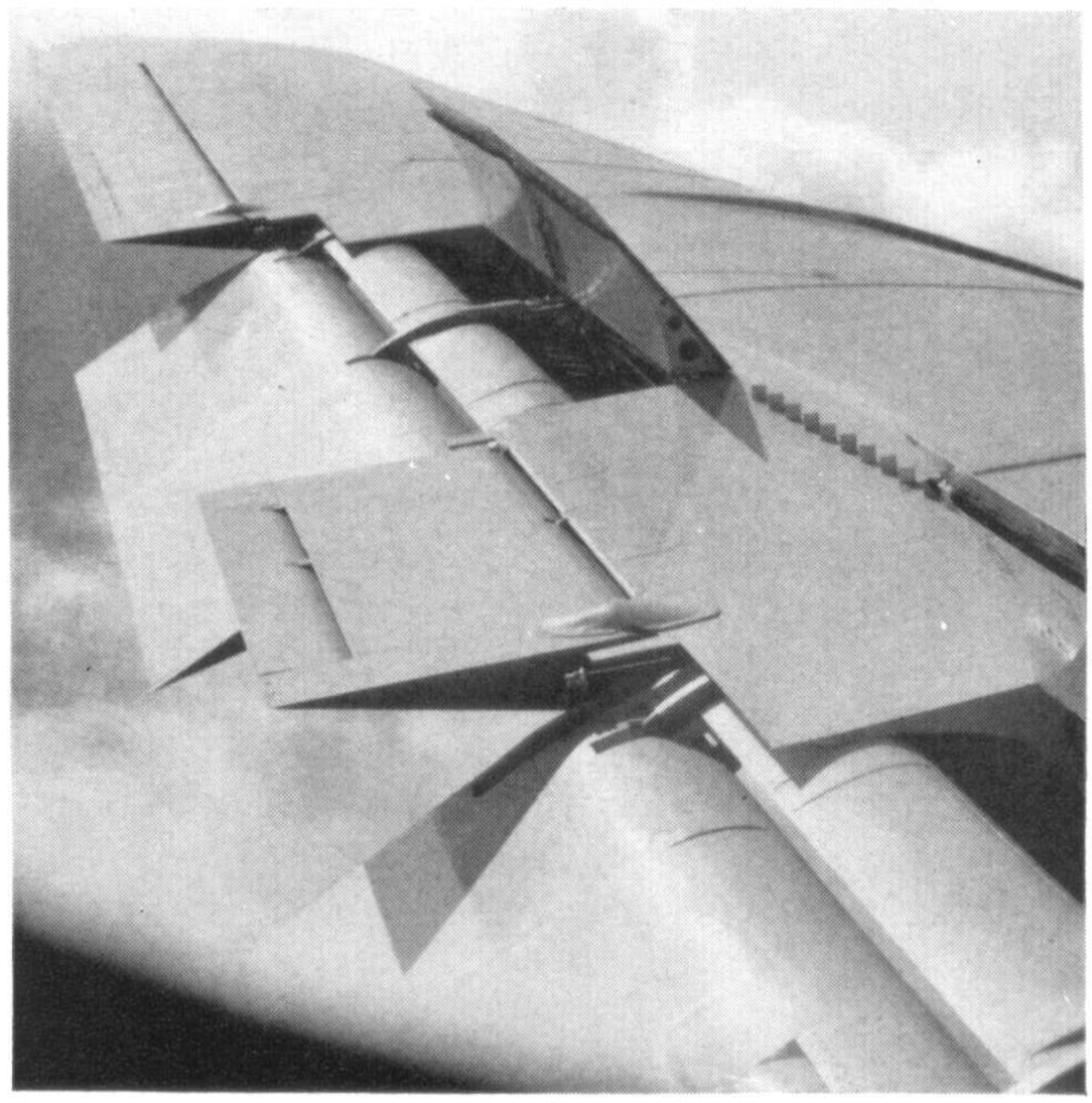
The Kreuger leading edge flaps. Designed to improve the aircraft's low-speed handling characteristics, these flaps extend automatically when the trailing edge flaps are lowered past the 9° position.

piece of steel used. As a direct result the company revised its methods of quality control.

The aircraft made its uneventful first flight on the 15th July 1954, again with Tex Johnston at the controls. During the first eight days of the Phase I flight trials the "Dash Eighty" made eight flights, and logged one minute short of seventeen hours in the air.

Three weeks after the maiden flight, on the 5th August, there was further trouble. As Johnston was bringing the prototype down after a test flight, there was a complete brake failure. In his words: "At the termination of the test a letdown and approach were made. Immediately after touchdown the brakes were applied with no results; in fact the airplane seemed to accelerate. The co-pilot's brakes were immediately actuated with no results. The emergency brake system was actuated—also with no results." The aircraft ran off the runway and ended up "in the rough", coming to rest on its nose after the nose wheel leg had snapped. Following this incident the hydraulic system underwent extensive redesign and rebuilding. Surprisingly little damage was caused to the "Dash Eighty", which was ready for flying again within weeks.

One of the most important parts of any test flying programme is the determination of the aircraft's performance envelope. What happened when the "Dash Eighty" was taken just a little too close to the speed of sound is now told, again in Tex Johnston's



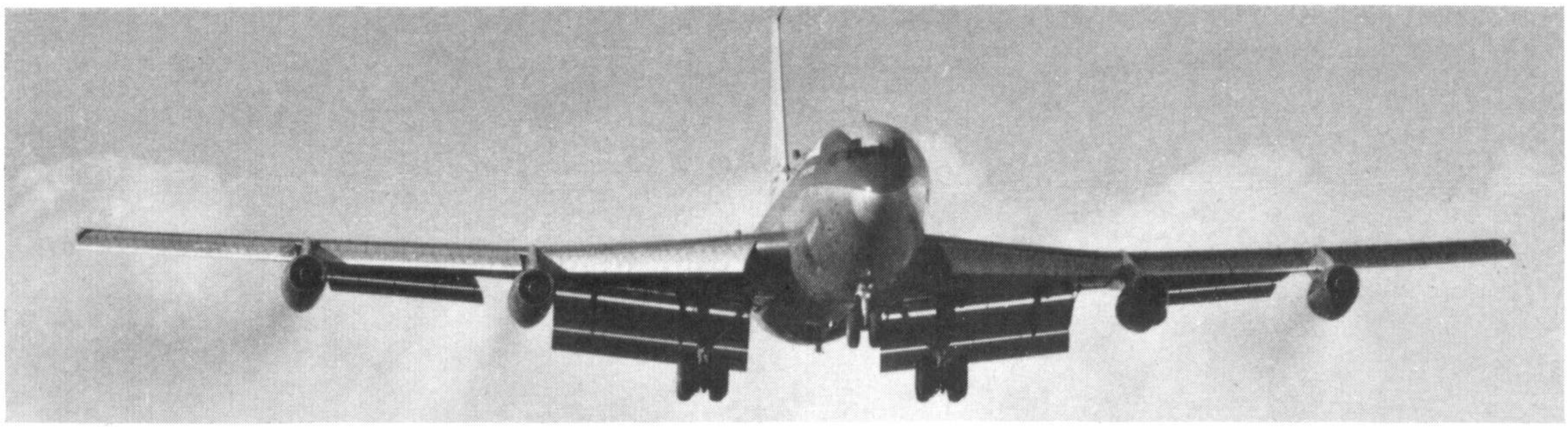
This interesting photograph shows the 707's wing control surfaces. The two flaps have been lowered, and the two spoilers (also used as air brakes) have been extended above the upper surface. Between the flaps is the inner aileron, outboard of the flaps is the outer aileron. The inner aileron is in operation at all times, while the outer one is used only at low speeds, being brought into operation when the flaps are lowered past the 23° position. Note the vortex generators between the two spoilers.

words: "Instantaneously severe rudder flutter was encountered. Power was reduced immediately and up elevator applied. As the airplane decelerated the flutter condition terminated. Even though no external structural damage to the airplane was experienced, I can assure you the resulting vibration was appreciable. This is borne out by the fact that the flight engineer's panel was ripped from its mounting." The cause of this vicious characteristic was traced to a tab on the fin, which received "immediate attention".

As the prototype's trials progressed, the jinx that had dogged the landing gear struck once again. Johnston had been giving the brakes some harsh treatment during one of the tests, and taxied in to have a brake check. Boeing ground engineers examined them and found that they were not excessively hot. Johnston taxied out again, took off, retracted the undercarriage and established the "Dash Eighty" in a climb to 35,000 feet.

> "At approximately 22,000 feet there was a terrific explosion—a sound similar to someone shooting both barrels of a 12-gauge shotgun in the cockpit—and I knew immediately the brake temperature had been too high. About this time the F-86 chase plane pilot reported black streaks appearing in

The "Dash Eighty" taking off. At the time this picture was taken the aircraft was fitted with a water spray rig for icing tests of the J 57 fitted in the starboard inner position.



The "Dash Eighty" in the landing configuration, showing the triple slotted flaps being tested for the 727. Note the lowered leading edge flap.

the vicinity of the wheel well doors. The gear was immediately extended, and sure enough some of the tyres were on fire and obviously blown out. When the airspeed was increased the tyre fire was extinguished and the airplane was returned to the airport. On this particular landing, I can assure you no brakes were required as we rolled to a stop, and power was required to taxi off at the 3,500 foot taxi strip."

Subsequent investigations revealed that the new type of brake, fitted after the original taxiing accident, was a very good heat reservoir. It stored the heat in the internal portion of the brake, and later radiated it out to the rim. Yet another type of brake was now fitted, and this proved to be successful. One by one the "bugs" were ironed out of the "Dash Eighty", as the Boeing test team got to know her better.

Thus far the Boeing company had soldiered on without a buyer for their revolutionary, but very expensive, transport. Then, on 1st September, 1954, came the first order: the U.S. Air Force wanted a batch of 29 jet tankers for Strategic Air Command. Boeing had been angling for such a contract for more than five years, and the design was ready. The company model number for the suitably modified 707 was 717-100A; to the Air Force it was the KC-135. The still gleaming prototype underwent the first of its many changes in shape: the underside of the rear fuselage was disfigured by a twenty-eight foot long "Flying Boom" refuelling pipe, similar to that fitted to the earlier KC-97. Still wearing its civil markings, the modified "Dash Eighty" made a series of link-ups with B-52's, to prove the compatibility of the two aircraft. Intentionally, no fuel was passed during these tests, which were successful.

CIVIL ORDERS

The U.S. Air Force's decision to use the KC-135 to flight refuel its intercontinental bombers was soon to result in orders for many hundreds of these tankers. This lifted a great weight off the shoulders of Boeing president William Allen: there was no need to fear for the sixteen million dollars the company had sunk in the 707 project. But the aircraft's potential as a profit-making passenger carrier had still to be realized. Boeing salesmen pestered airline executives all over the world, senior pilots came to Renton to fly the "Dash Eighty", but while there was much interest there were no takers. To change over to jets meant risking very large sums of money on a design which had still to be proven. Nobody wanted to be first.

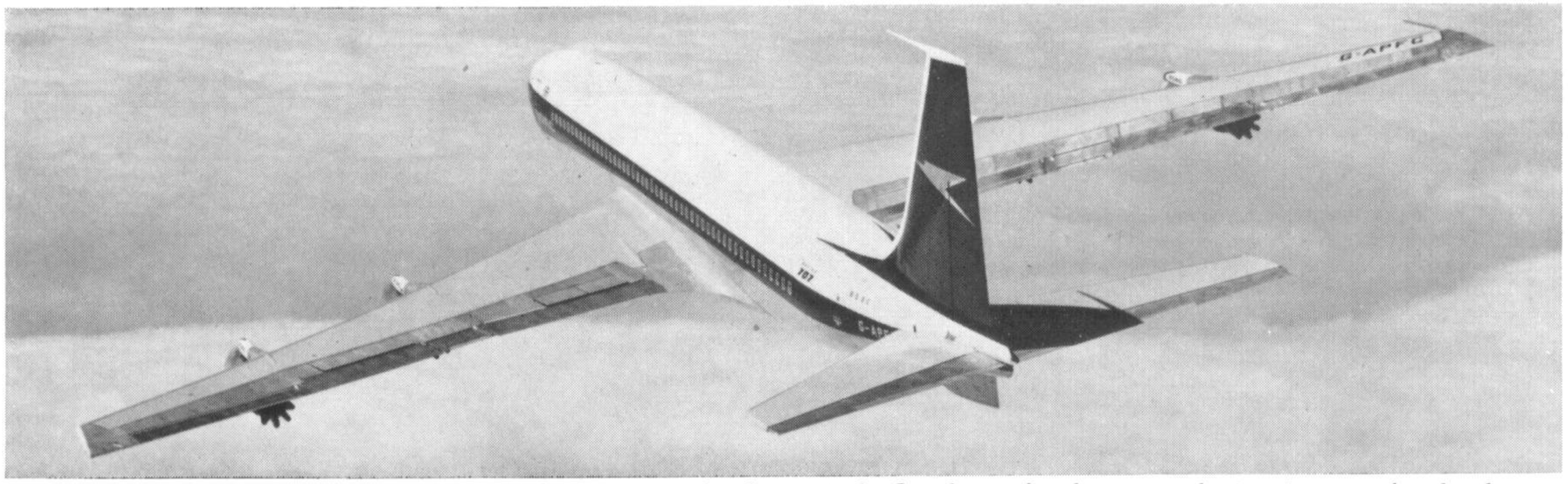
Then, on the 13th October 1955, just over a year after the "Dash Eighty's" first flight, Pan American broke the ice. The airline announced an order for 269 million dollars (about £96 million), for twenty 707's and twenty-five of the rival Douglas DC-8 jets; the latter machine was ordered off the drawing board, and was not to fly until May 1958. The Pan-Am order released the flood gates. Within a month American Airlines ordered thirty 707's, and then eleven airlines made up their minds and bustled for places in the delivery queue: Continental, Braniff, Sabena, Air France, T.W.A., B.O.A.C., Lufthansa, Air India and Qantas. When Pan-Am introduced the 707 to the North Atlantic route, on 26th October 1958, there were orders for 184 airliners based on the original "Dash Eighty".

By April 1967 a total of 568 Boeing 707 civil variants had been delivered, and a further one hundred and fifty remained on the order books. These aircraft fell within five main categories, identi-

A 707-320C beginning to take shape; the fin and engines have still to be fitted.

The place—any of the world's major airports. The time—any hour of day or night. Air transport, particularly air freight, is a twenty-four-hour-a-day business. Under the glare of floodlights a B.O.A.C. Boeing 707-336C takes on its load.

(Photo: B.O.A.C.)



Unusual view of a 707, in this case a -436 of B.O.A.C. The distinctively fluted sound reducers on the jet pipes can be clearly seen. (Photo: B.O.A.C.)

fied by the "hundreds" figure of the three digit suffix which follows the type number "707":

707-120 series. The initial production version of the 367-80 prototype, the -120 is slightly larger, heavier, and has more powerful engines. The power is from four Pratt and Whitney JT3C's of 12,500 lb. thrust each. All up weight 257,000 lb.

707-220 series. Identical in size to the -120, the -220 is fitted with more powerful Pratt and Whitney JT4A engines, developing 15,800 pounds thrust. Only five examples of this version were built, all for Braniff International; the airline needed jets with improved airfield performance to work its Latin American routes, which often call for take-offs from high altitude strips at high ambient temperatures.

707-320 series. The Intercontinental version of the 707, the -320 is somewhat larger than the two earlier models. Powered, like the -220, by four JT4A engines, it has an increased fuel tankage which gives it a still air range of 5,860 miles with a payload of 21,400 lb. (compared with 4,040 miles with 23,400 lb. for the -120). Numerically by far the most important of the 707 variants, production of the -320 numbers 251. A further 122 are on order. All up weight 315,000 lb.

707-420 series. An Intercontinental version, exactly similar to the -320 but powered by four Rolls Royce Conway 508's developing 17,500 lb. thrust each. Thirty-seven examples of this version were built before production ended.

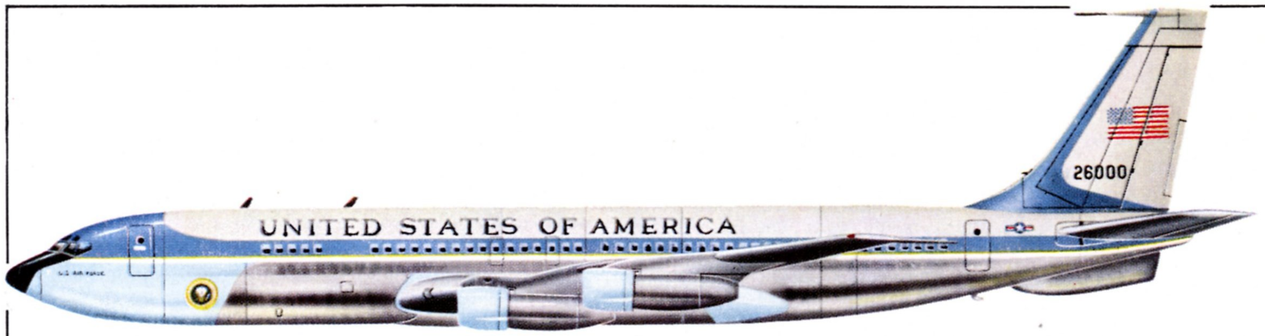
720 series, also 707-020 series. Both these type numbers refer to the same aircraft, a short and medium range transport developed from the 707-120. In spite of its external similarity with the other models, the 720 is essentially a new design. The fuselage of this aircraft is some eight feet shorter than that of the -120. All up weight 229,000 lb.

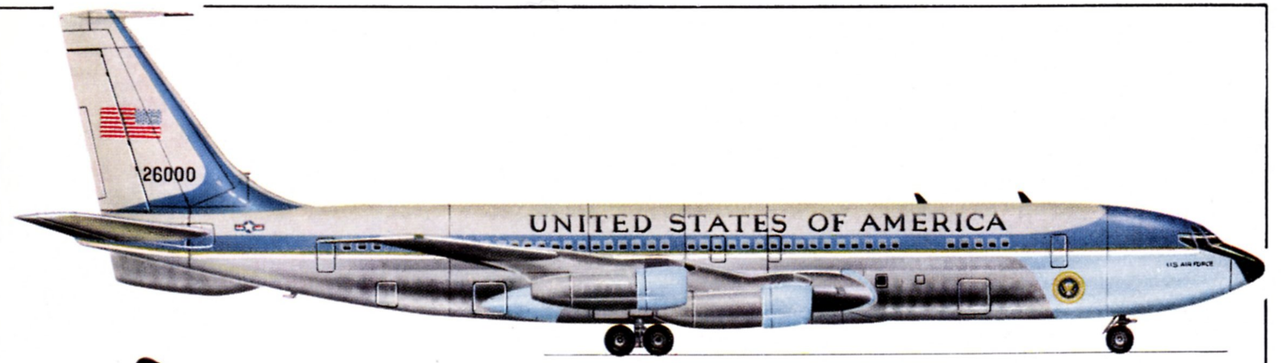
The last two digits of the "dash number" indicate the original customer. This code runs as follows:

21 Pan American 22 United Air Lines
23 American Airlines 24 Continental Airlines
25 Eastern Airlines 27 Braniff
28 Air France 29 Sabena
30 Lufthansa 31 T.W.A.
36 B.O.A.C. 37 Air India
38 Q.A.N.T.A.S. 40 Pakistan International
41 Varig 47 Western Air Lines
48 Irish International 51 Northwest Orient
53 U.S.A.F. 58 El Al
59 Avianca 60 Ethiopian
61 F.A.A. 62 Pacific Northern
65 Cunard Eagle 68 Saudi Arabian
73 World Airways

The "dash number" may be suffixed by the letters 'B' or 'C'. The 'B' (suffixing 707's and 720's) indicates that the aircraft is powered by Pratt and Whitney JT3D turbofans giving 18,000 lb. thrust, while the 'C' (suffixing 707's only) indicates a cargo version of the 707-320B, which may be converted to carry passengers. The latter is fitted with the large (91″—134″) loading door, cargo lashing points, and has a strengthened floor.

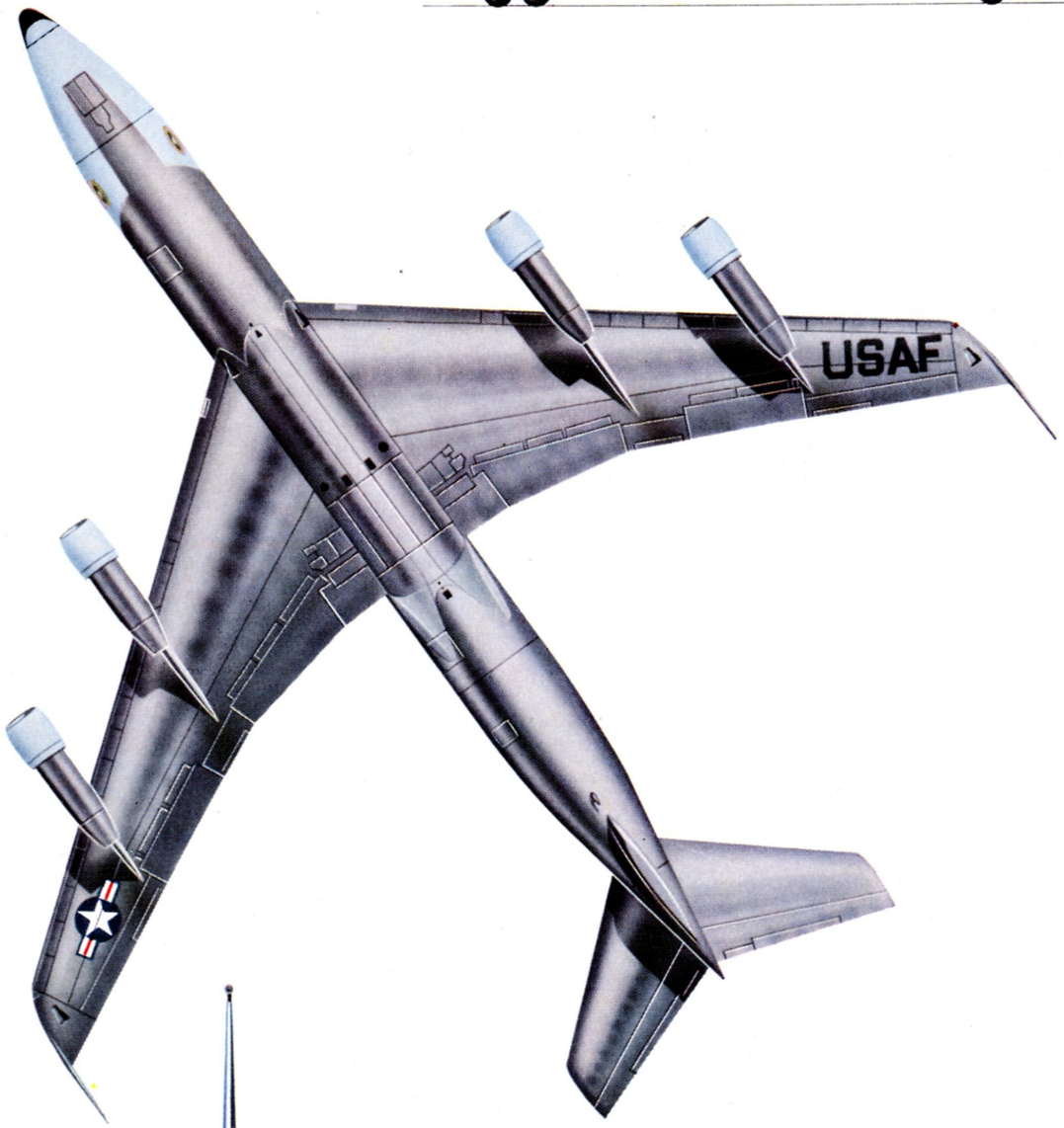
Boeing 707 tails: (below) *the original short fin, as fitted to the early models; and* (right) *the modified fin with an extra 2 ft. 11 in. at the top to improve directional stability. The under fin, fitted to some 707's, provides warning of an excessive nose-up attitude during take-off.* (Photo: B.O.A.C.)

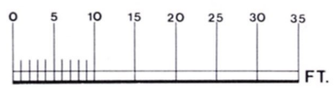




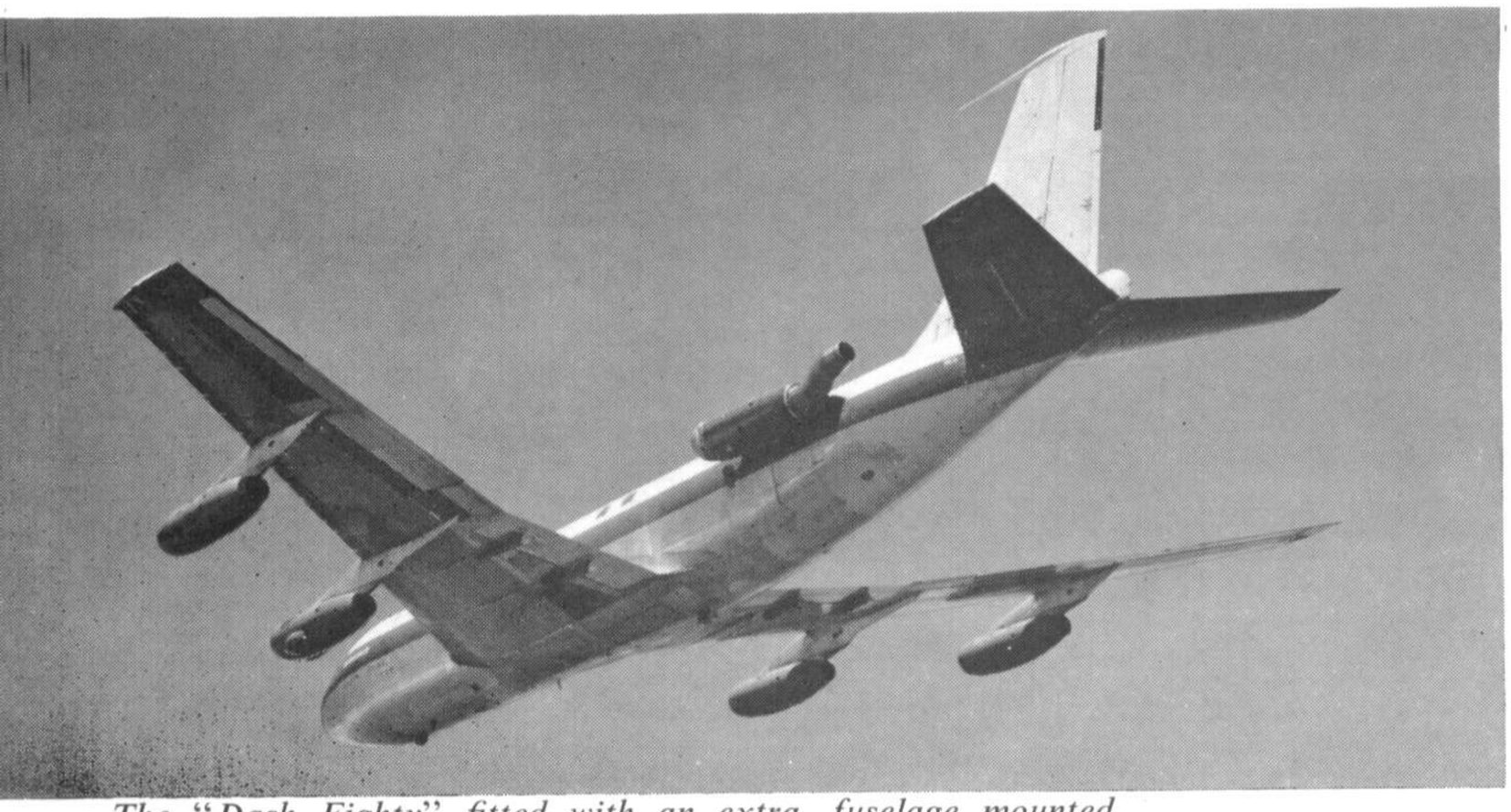
BOEING 707-320B (military designation **VC-137C**), serial **62-6000**, operated as the personal aircraft of the President of the United States by the 98th Air Transport Squadron, 89th Military Airlift Wing, U.S.A.F., from Andrews Air Force Base near Washington, D.C. It was in the stateroom of this aircraft, on the afternoon of November 22nd 1963, that Lyndon B. Johnson took the Presidential oath; the aircraft stood at Love Field, Dallas, Texas. The Presidential aircraft is known as "Air Force One".

Seal of the President of the United States, carried on the forward fuselage.





(Above) *When fitted with the Bendix AN/AMQ-15 weather radar, the nose of the "Dash Eighty" assumed a new shape. At the time this photo was taken engine tests were also in progress. The outboard engines were JT-3's, No. 2 was a J 75 and No. 3 was a J 57.*



The "Dash Eighty" fitted with an extra, fuselage mounted, engine. This was one of a number of Boeing 727 features which were first tested on her.

Thus a Boeing 707-336C is an intercontinental passenger/freighter for B.O.A.C., powered by JT3D turbofans.

IN SERVICE

Today the most numerous of the intercontinental airliners, the 707 is to be seen at almost every major civil airport. Even the Chinese, who maintain their self-imposed isolation, catch the occasional glimpse of this sleek aircraft: both Air France and Pakistan International fly -320's into Peking.

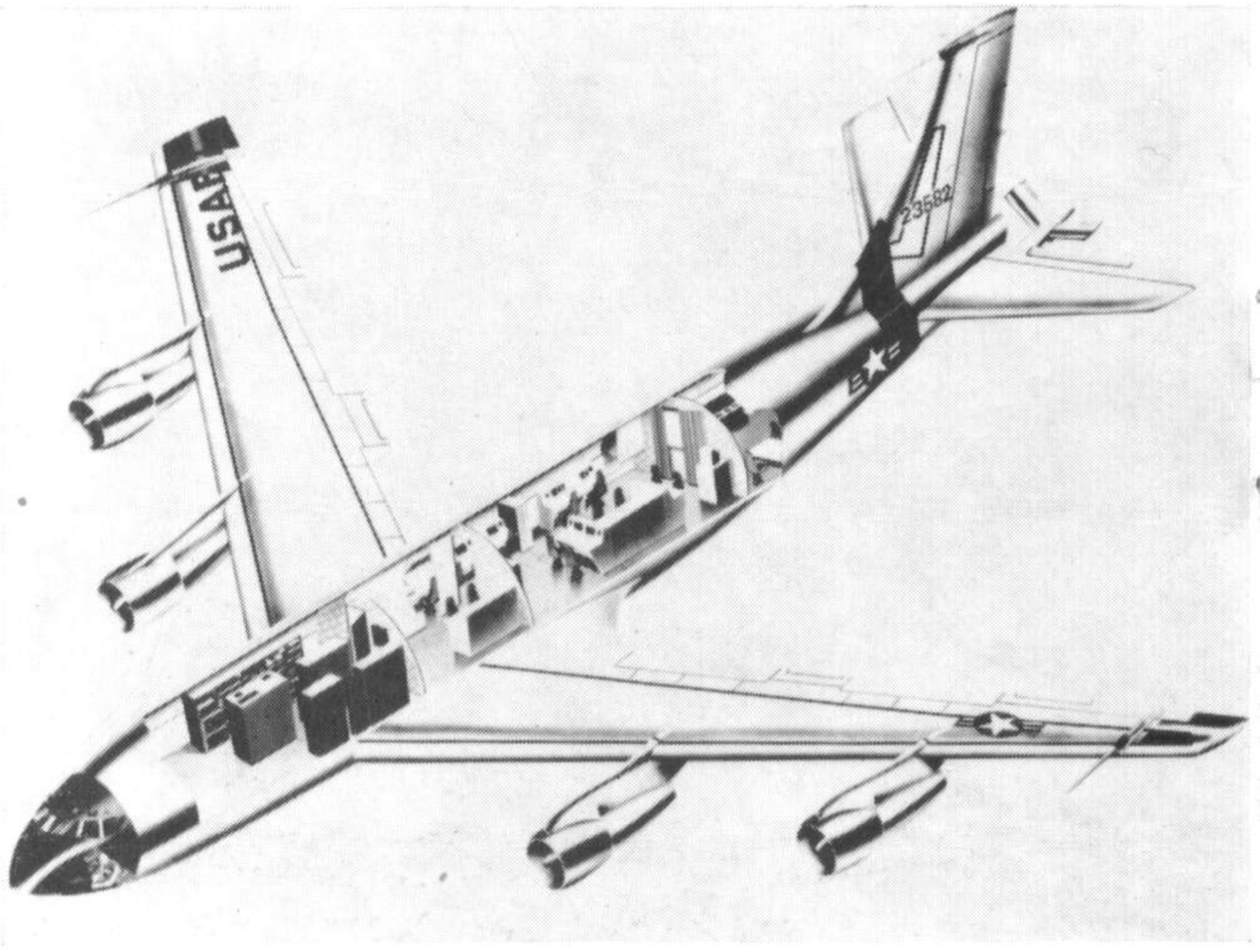
A big and fast machine in large scale service, it is not surprising that the 707's have created some spectacular records. On 23rd February 1960 P.A.A. Captain Scotty Lewis, riding a mighty 145 m.p.h. jetstream in a -320, covered the 1,885 miles from Tokyo to Hong Kong at a phenominal ground speed of 760 m.p.h. The longest commercial jet route is thought to be the 5,680 mile non-stop trip from Paris to Rio de Janeiro, operated once a week by Air France with -320B's.

For human load carrying perhaps the most remarkable flight was in July 1960: a Sabena -320 bore 301 people, evacuees and crew, from Leopoldville—then the capital of the Congo—to Brussels, a non-stop flight of some four thousand miles. Most of the passengers were women and children.

One -320B was bought by the United States Government and fitted with staterooms, sleeping berths and an elaborate communications centre, for service as the President's personal aircraft. This machine, serial number 62-6000, is operated by the 98th Air Transport Squadron of the 89th Military Airlift Wing and is based at Andrews A.F.B. near Washington. The service designation of this machine is VC-137C.

History was made in the VC-137C on the afternoon of the 22nd November 1963, as it sat on the ground at Love Field, Dallas, Texas. For it was in the stateroom of this aircraft that Lyndon B. Johnson was sworn in as President of the United States. While he was actually taking his oath the body of his murdered predecessor, John F. Kennedy, lay in a coffin in the tail.

But the greater part of the 707's work is the mundane business of moving people comfortably and profitably from A to B. As far as the airline business is concerned, no news is generally good news. And the fact that the Boeing jet has come to be taken almost for granted is perhaps the greatest compliment



Cutaway of the airborne command post version of the KC-135, the EC-135C. The forward compartment houses the communications equipment, the second compartment is the radio operators' station, while the third houses the general and his operations team. The rear section of the aircraft houses the galley and rest area. Note the additional aerials fitted to the wings of this aircraft. (Photo: U.S.A.F.)

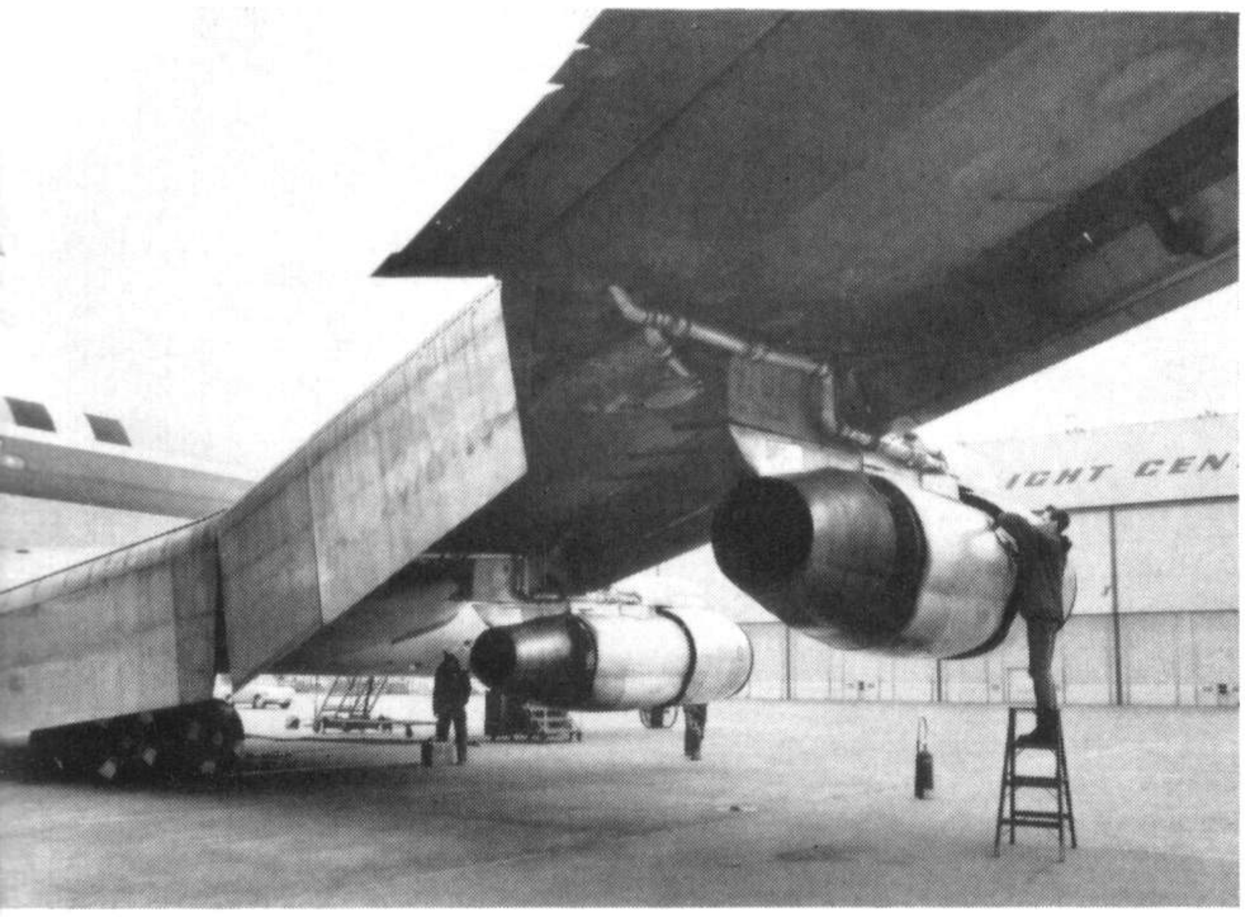
(Above) *Modified still further with a twenty-wheel rough field landing gear, the "Dash Eighty" made a series of landings and take-offs from the untreated sand and mud surface of Harper Dry Lake, California.*

(Right) *This converted KC-135—the refueling operator's position has been faired over, but may still be seen—operates in the high level photographic rôle with the Military Airlift Command, under the designation RC-135A. Note the camera ports under the nose.*

of all. Not that this reliability has been to everyone's liking. To quote Lufthansa Captain Bernhard Jope*. "We used to call the Conny (L. 1649) the safest three-engined aircraft flying, so often did we lose an engine. Today our Boeing 707's never seem to have engine failures—to the chagrin of our stewardesses, who used to enjoy their unscheduled stops in interesting places."

Together with its rivals the 707 has revolutionized the air passenger business. Now, so quietly that it has almost passed unnoticed by the man in the street, a second revolution is taking place.

**Jope had a distinguished career in the Luftwaffe during the Second World War, flying with KG 40 and later as commander of the famous KG 100. See* Profile *No. 99.*

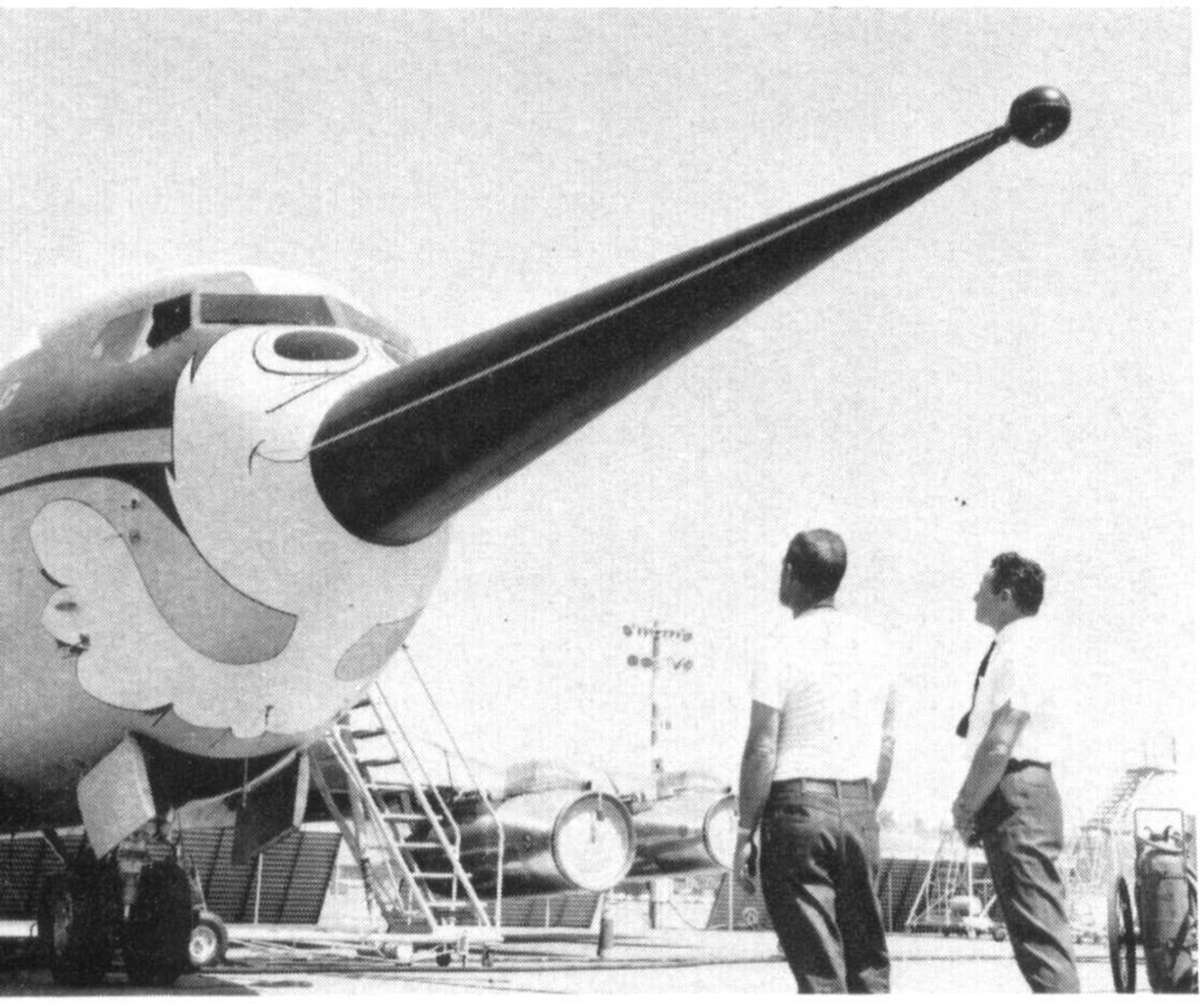


One of the important advantages of the jet engine is that it is able to generate considerably more power than the piston engine, without a commensurate increase in weight. It is this that gives the jet its spectacular increase in performance over the piston engined airliner. But also—and this is important—the additional power enables the jet aircraft to lift itself off the ground with a much greater payload. For example, the DC-4 weighed about 35 tons fully loaded, of which up to fifteen tons was payload. A Boeing 707-320C can carry a payload of forty-three tons, eight tons *more* than the all-up weight of the DC-4. Moreover, the new freighter is able to lift this load together with sufficient fuel for a 3,000 mile flight—more than twice as far as the DC-4 could have carried its fifteen ton load.

Of course, even the modern airliner lifting forty tons at a time is hardly in the same league as a cargo ship carrying 7,000 tons. Nor is air transport suitable for very large or bulky cargoes. But on the other hand an aircraft can do one round trip to a destination 3,000 miles away once every twenty-four hours. Not only is it for perishable goods—and the word "perishable" covers a wide spectrum, from radio isotopes to Paris fashions—that air transport provides the answer to an otherwise insoluble problem. Exporters in general have been quick to see the advantages of this means of rapid delivery.

Today the air freight business is booming, with

Yet another modification to the long suffering "Dash Eighty" was the introduction of "blown" flaps. The external ducts carrying the high pressure air to the tops of the flaps can be seen clearly.



Latest of the "faces" of the "Dash Eighty" is this fifteen-foot-long probe which houses an aircraft response sensing system. The ball at the end of the probe is solely to protect the fragile sensing vanes and is removed prior to flight.

a growth rate of thirty per cent. per year. It is no coincidence that 81 of the 150 Boeing 707 variants on order at the time of writing are -320C convertible freighters.

THE VENERABLE "DASH EIGHTY"

The reader will recall that we left the 707 prototype, the "Dash Eighty", testing out the "Flying Boom" refuelling system for the KC-135. But her career did not end there; far from it. She has become the test bed for a host of modifications for her own generation of airliners, and their successors. One of the early additions was a set of Kreuger leading edge flaps, soon followed by Boeing developed sound suppressors and thrust reversers for the jet engines. All these were later fitted to production aircraft.

Many of the different types of engine later fitted to 707's, 720's, 727's and KC-135s were tried out on the "Dash Eighty". For airborne icing tests of the J-57 one of these engines was fitted in the No. 3 nacelle, and a spray rig was mounted in front of the intake.

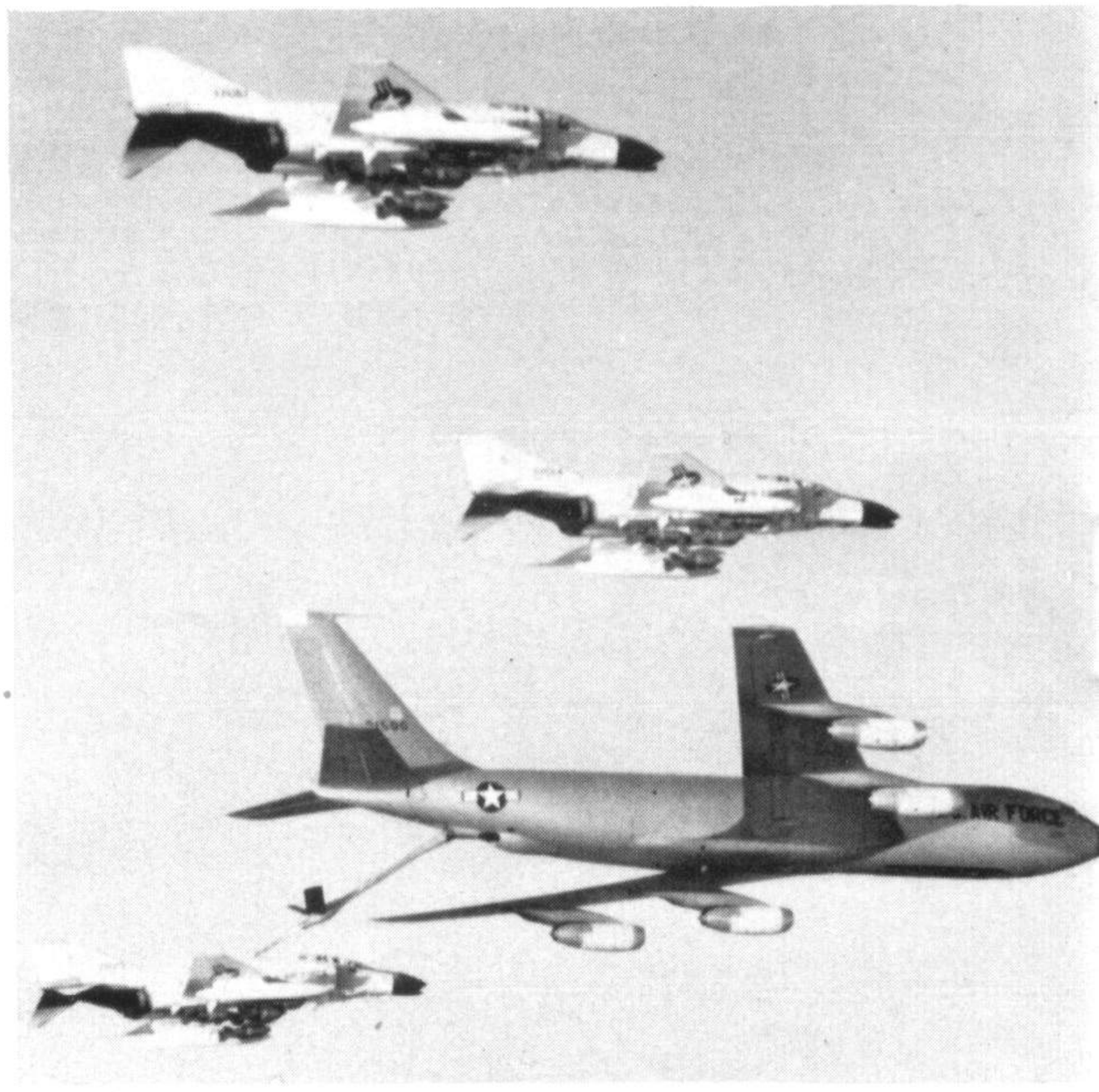
To test the Bendix AN/AMP -15 weather radar, amongst other things, the "Dash Eighty" was given revised nose contours. When these trials were completed the prototype regained her original nose shape for the flight testing of a number of features intended for the Boeing 727. These necessitated the mounting of a fifth engine on the port side of the rear fuselage, fitted with a dog-leg tail pipe to carry the jet's blast over the tailplane. Additionally, 727-type flaps were fitted to the "Dash Eighty's" wings. To save time these were bolted on, fixed in the down position.

In 1963 the National Aeronautics and Space Administration (N.A.S.A.) leased the "Dash Eighty" to test the feasibility of "blown" trailing edge flaps as a means of reducing the landing speed of heavy jet aircraft, under an $800,000 contract. Air was bled from the high pressure section of each of the four engines, and fed to two main supply ducts running along the rear of each wing main spar. From there the air passed through ejectors, where it mixed with the cooler outside air and passed across the top of the flaps at 880 feet per second. A larger, -320 type tail plane was fitted, with an inverted (upwards pointing) leading edge slat, to enable the aircraft to be trimmed during the blown flap phases of the flight. By using thirty per cent. of the available thrust for boundary layer control, it was possible to reduce the airfield approach speed from 150 m.p.h. to 100 m.p.h. When the system was taken to its limit the "Dash Eighty" was flown at speeds down to 75 m.p.h., without stalling. During these very low speed tests the limiting factor was found to be the control surfaces, which were just not designed for such a task.

For yet another test the prototype was fitted with a rough field landing gear comprising twice the number of wheels usually fitted: eight instead of four on each main leg, and four instead of two on the nose leg, and instead of inflation to the more usual 80 pounds per square inch, the tyres were pumped up to only 25 p.s.i. Retaining the blown flaps and with the new undercarriage, the "Dash Eighty" carried out a series of landings and take-offs from the untreated sand and mud surface of Harper Dry Lake, in Southern California.

The latest test programme for the "Dash Eighty" has changed her shape once again. The prototype now carries a distinctive fifteen foot long needle nose, which houses an aircraft response sensing system. The object of the trial is to study the low speed handling characteristics of projected supersonic transport (SST) designs. The co-pilot's position has been set up for the SST evaluation. The control column and rudder pedals have been adapted to operate through a special analog computer aboard the aircraft. Should a left turn be made from the co-pilot's position, for example, signals from the control column and the left rudder pedal are sent to the computer, and from it signals pass to the aircraft's flight control system. The response is adjusted by the

The refuelling of tactical strike aircraft in flight is one of the important innovations tried out in action for the first time during the Vietnam conflict. Here a KC-135 tops up the tanks of a flight of heavily laden F-4C Phantoms prior to a strike on a target in North Vietnam. (Photo: U.S.A.F.)



A C-135F (the "K" prefix is not applied to these aircraft) of the French Air Force refuels a Mirage IV. Note the adaptor to enable the boom to be used for the probe and drogue refuelling method. Because of its appearance as it hangs from the rear of the tanker, while the latter is on the ground, the adaptor is widely known as "The Limp Dick". (Photo: French Air Force)

computer to simulate the response of the SST design being studied.

For the "Dash Eighty" the last thirteen years have been adventurous indeed. In her day she flew faster than any other airliner in the world. And in her day she flew slower than the great majority of them could. In all probability she is the most modified aircraft ever to fly. And there's life in the old girl yet.

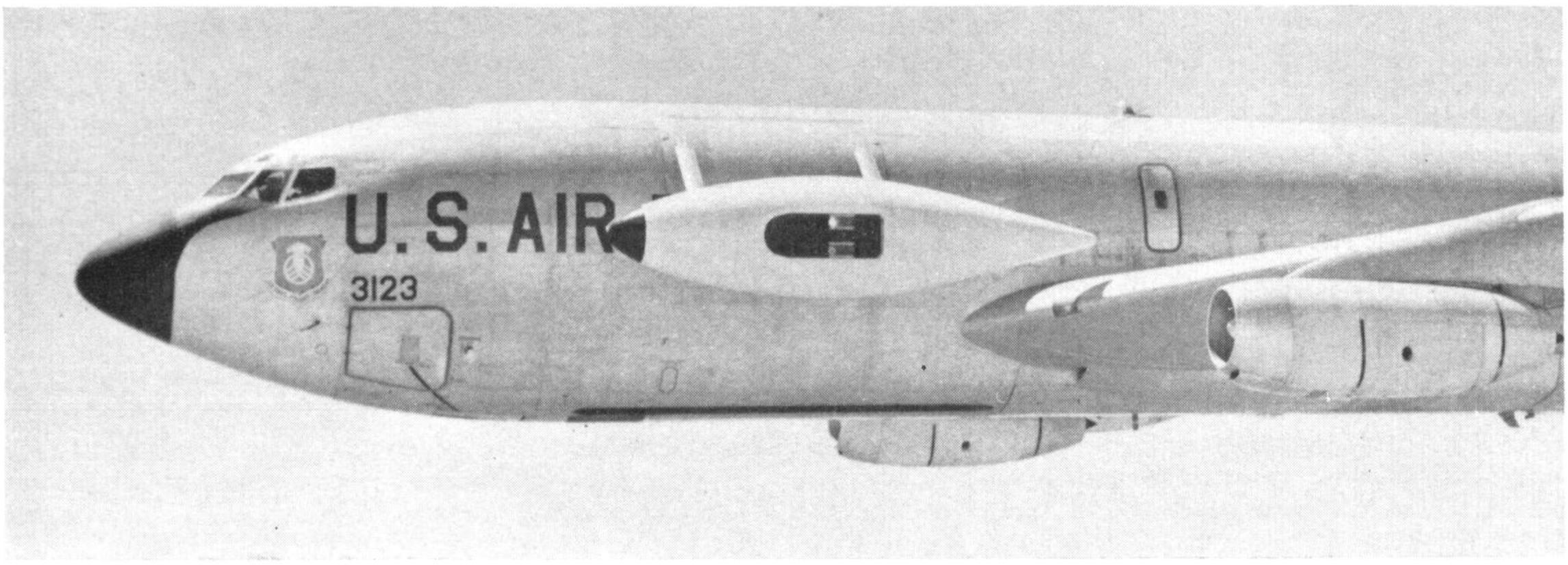
"Grotesque" is the only word to adequately describe the eight ex-Military Airlift Command C-135's which have been modified into airborne radio relay stations under the designation EC-135N. The eleven foot long "schnoz" houses a seven foot diameter scanner dish. (Photo: U.S.A.F.)

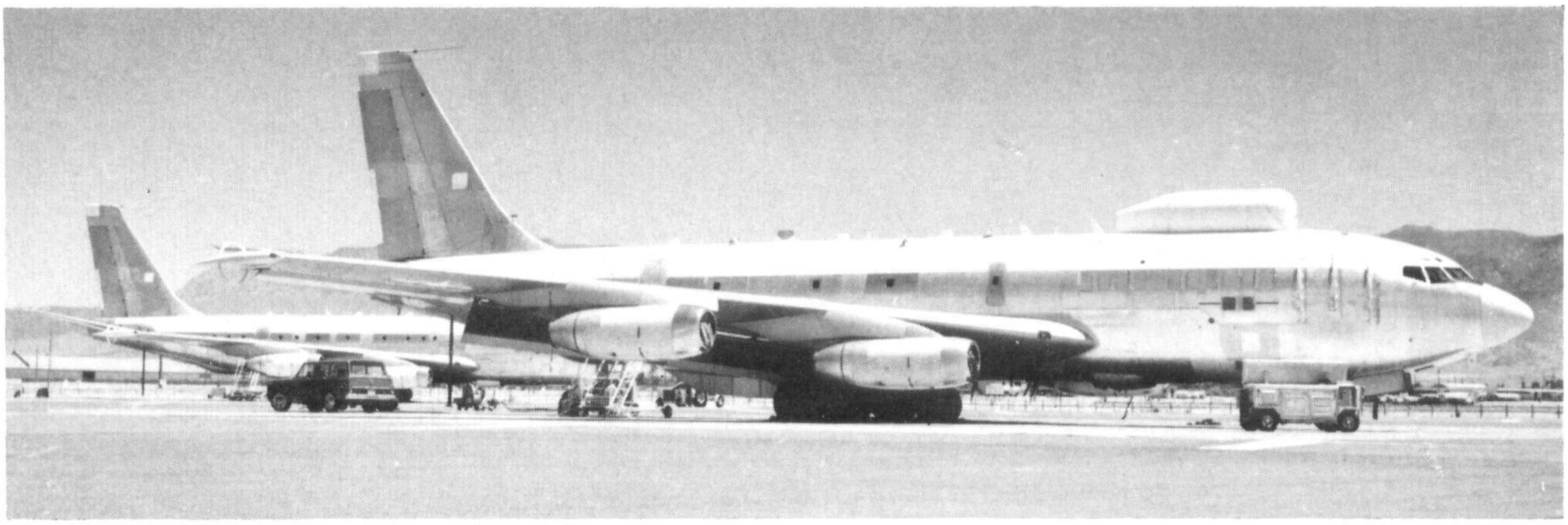
MILITARY VARIANTS

While the 707's and 720's were revolutionizing the civil transport scene, and the 367-80 prototype was appearing in ever new and exotic shapes, Boeing was delivering KC-135's to the U.S. Air Force by the hundred. The first of these jet tankers entered service on 18th June 1957, and deliveries of this and other military 707 variants continued until January 1965, when the 820th was handed over.

The basic fuel transfer method used by the KC-135 is the Boeing-developed "Flying Boom". The boom itself consists of four concentrically machined aluminium tubes. After it has been lowered to a position below the rear fuselage, the boom can be hydraulically extended to a maximum length of 47 feet. The boom operator lies prone in the rear of the tanker, from which position he "flies" the rigid boom using the two "ruddervators" to mate it with the input socket of the receiving aircraft. The advantage of this system over the simpler "probe and drogue" method is that the fuel can be transferred under high pressure, and rates of up to 1,000 Imp. gallons per minute are possible. If it is wished to transfer fuel to aircraft fitted with refuelling probes, a simple

The pod mounted on the freight door of this KC-135 contains the Northrop ALOTS airborne missile tracking system. (Photo: U.S.A.F.)





These hump backed NKC-135A's carry infra red, ultra violet and optical scanning equipment for data collection during nuclear tests. Note the unusual sensor built into the starboard wing. These aircraft fly clockwise round the explosion while collecting their information, and therefore have all markings on the starboard side painted out to avoid flash burns. On their port sides these aircraft carry the normal markings. The badges on the fuselage are those of the Air Force Systems Command and the A.F. Special Weapons Centre. Two NKC-135A's were built with sensors looking out to starboard, one with sensors looking out to port.

adaptor is fitted in the end of the boom and the "probe and drogue" system is used.

The KC-135 can carry up to 25,980 Imp. gallons of fuel, all of which is usable by the tanker itself. On the other hand all, bar that in the 833 gallon reserve tank, can be transferred to the receiver aircraft.

With the exception of a single 1,810 gallon tank in the after fuselage, all the fuel cells are either in the wings or underneath the main fuselage compartment. The tankers have an almost entirely clear upper fuselage and are thus readily convertible into troop transports (80 fully equipped men) or freighters (up to 35·7 tons). The large cargo door is standard on all KC-135's. To facilitate handling of heavy loads, an electrically operated cargo hoist is fitted to the top of the upper fuselage; it moves along on a pair of rails, and is able to position loads weighing up to 6,000 pounds anywhere in the upper fuselage.

KC-135's have been doing sterling service supporting the air operations in Vietnam. There, for the first time, the advantages of flight refuelling for tactical air operations are being demonstrated. Quite apart from the obvious advantages of giving small strike aircraft the range to hit the most distant targets, there are other, less obvious ones. Strike aircraft which have run short of fuel, perhaps even with some of their tanks punctured by enemy action, are able to return safely after refuelling. The tankers also give invaluable support for rescue operations. In the words of one KC-135 pilot:

> "If a pilot is down in unfriendly territory, fighters in the general area of a downed pilot can suppress ground fire and enemy activity while helicopters are dispatched for the pickup. The cover fighters can shuttle back and forth to the tanker, take on fuel, and return to the rescue area. It turns a two hour F-105 flight into one of several hours."

During air operations over North Vietnam a "cab rank" of KC-135's maintains station over the Gulf of Tonkin. By extending the range of the strike aircraft the KC-135's make possible the rapid reinforcement of the war zone. A typical ferry mission comprises a cell of three tankers and six fighters. These fly from the Western United States to South Vietnam, stopping only at Hawaii and Guam. During the long over-sea legs the tankers are responsible for the navigation, and the fighters tag along in loose formation.

Not all the 820 military 707's were delivered as tankers. Forty-five were pure passenger-cargo aircraft for the Military Airlift Command*. These machines, with the service designation C-135A and the Boeing model number 717-157, were not fitted with refuelling equipment. The last thirty of these aircraft to be delivered were completed as C-135B's, differing from the earlier models in the installation of turbofan engines.

* *Formerly Military Air Transport Service.*

Boeing 720-048, EI-ALA "St. Patrick" of Irish International Airlines.

Boeing 720-027, N7076 of Braniff International.

Ethiopian lion insignia, superimposed on red panel behind cockpit.

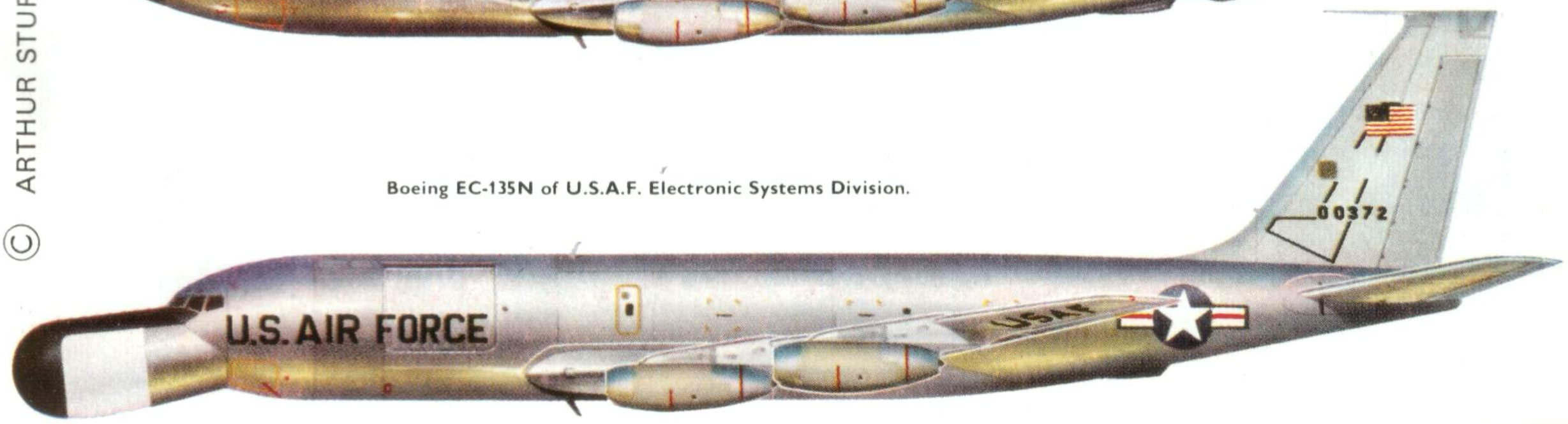
Boeing 720-060B, ET-AAG of Ethiopian Airlines.

Boeing KC-135 of U.S.A.F. Strategic Air Command.

S.A.C. insignia.

Boeing C-135F of French Air Force.

Boeing EC-135N of U.S.A.F. Electronic Systems Division.



One of the most important tasks undertaken by the 135 is that of airborne command post (A.C.P.), performed in the Strategic Air Command by the EC-135H. These aircraft, one of which is always airborne, carry a normal complement of five crewmen plus one general officer and his ten-man staff. The general is in radio contact with all S.A.C. operational facilities, and is thus able to initiate a retaliatory blow even if a surprise attack were to knock out the main headquarters. The A.C.P.'s are able to take on fuel from KC-135's through the nose in the normal way. In addition they can refuel from bombers, by connecting the "Flying Boom" and reversing the action.

Essentially the 135 is an aircraft with a large and capacious hold, able to fly high and fast. This has been the key to its great versatility within the U.S.A.F. Most grotesque of the reshapings of the 135, to date, has been the addition of a blunt "schnoz" nearly eleven feet long. This dome houses a scanner dish seven feet in diameter, linked to special equipment housed in the body of the aircraft. Eight machines have been so modified, for use as airborne radio relay stations, to improve communications between astronauts and their headquarters on earth.

Yet another change in the 135's shape appeared when the Northrop developed Airborne Light Optical Tracking System (ALOTS) was fitted. The system is used for photographing missiles in flight down the Cape Kennedy range. Housed inside a streamlined canister, the optical tracker is mounted externally on the port side of the nose, on the main cargo door. The heart of ALOTS is a 70 mm. high resolution ciné camera, which is able to resolve to within 2 seconds of arc. It is thus able to photograph clearly a 7 inch target at 10 miles, or a 30 foot target at 500 miles. The big advantage of such tracking is that it takes place at high altitude, clear of all weather interference.

For use as data collectors during nuclear tests, a number of 135's were fitted with infra-red, ultra-violet and optical scanners looking through specially ground windows cut along the side of the fuselage, or mounted on a "hump" on the top of the fuselage. These machines were also used during operation SEX. SEX stood for Solar Eclipse Expedition, 1965, and the 135's were charged with chasing and observing the solar eclipse as it passed swiftly across the earth's surface.

No description of the military 135's is complete without a few words on the dozen tankers supplied to the French Air Force. Designated C-135F, these aircraft are used as refuellers for the Dassault Mirage IV bombers which make up the French nuclear strike force, (*Force de Frappe*). To date no photographs have been released showing C-135F's bearing unit markings. We asked the French Air Force for information on the units operating these aircraft, but were told that none could be given "*en raison du secret militaire*".

Ten years and some two million flying hours have slid under the wings of the various 135's. And where is the first Stratotanker now, the first of nearly fourteen hundred Boeing 707 variants to enter service ? Decorating the entrance to some air force station ? Making the centre piece of a children's playground ? Sold at a knock-down price to some little-known charter company ? None of these. It is serving with the Tactical Air Command as an airborne command post, doing a useful job quietly and without fuss.

The order and delivery figures quoted are those current on 11th April 1967.

The author wishes to acknowledge the invaluable help he has received from the Boeing Company.

DELIVERIES

Deliveries of Boeing 707's and 720's, up to April 11th 1967:-

Boeing 707-120:
American, 25; Continental, 5; Pan-Am, 8; Qantas, 7; TWA, 15, U.S.A.F. 3.

Boeing 707-120B:
American, 16; Qantas, 6; TWA, 32.

Boeing 707-220:
Braniff, 4.

Boeing 707-320:
Air France, 21; Pan-Am, 26; Sabena, 7; South African, 3; TWA, 12.

Boeing 707-320B:
Air France, 8; Air India, 3; Aerolineas Argentinas, 4; El Al, 2; Lufthansa, 12; Northwest, 5; Pan-Am, 24; South African, 2; TAP, 2: TWA, 22; U.S.A.F., 1.

Boeing 707-320C:
Air France, 2; Air India, 1; Airlift International, 1; American, 12; B.O.A.C., 2; Barniff, 6; Continental, 8; Flying Tiger, 4; Irish, 3; Lufthansa, 3; Northwest, 18; Olympic, 3; Pan-Am, 15; P.I.A., 2; Qantas, 8; Sabena, 3; South African, 2; T.W.A., 7; Varig, 3; World Airways, 6.

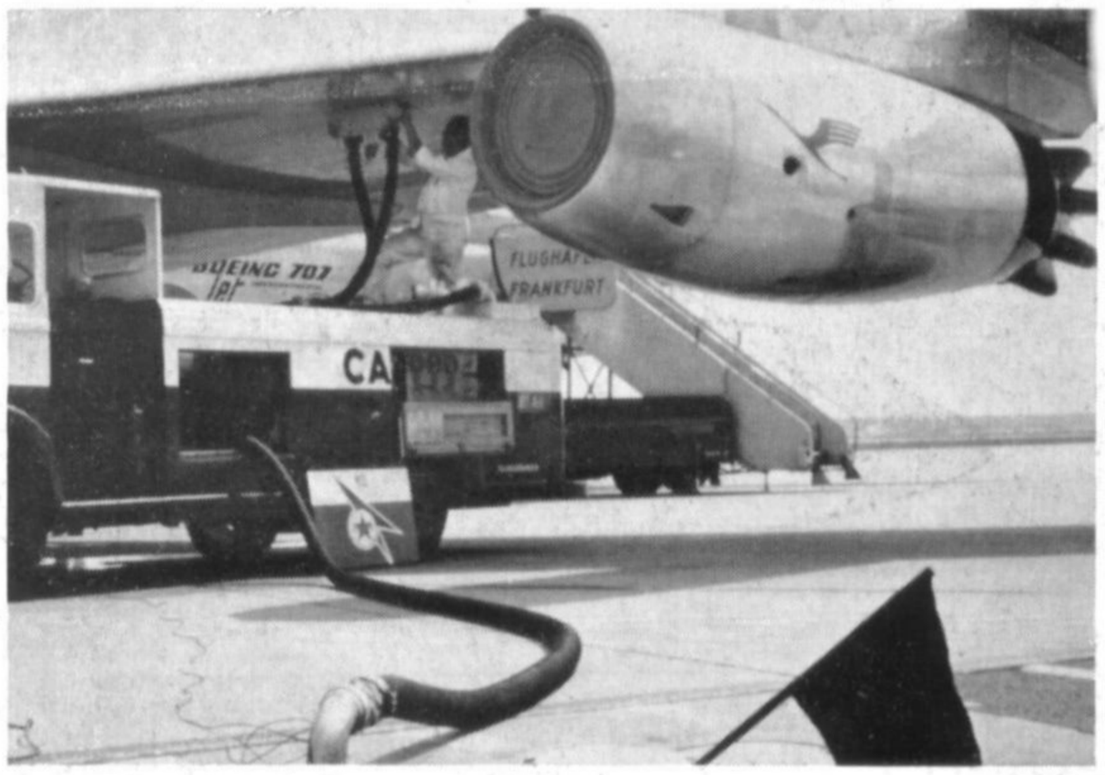
Boeing 707-420:
Air India, 6; B.O.A.C. 19; Cunard (now B.O.A.C.), 2; El Al, 3; Lufthansa, 5; Varig, 3.

Boeing 720:
American, 10; Braniff, 5; Eastern, 15; F.A.A., 1; Irish, 3; Pacific Northern, 2; United, 29.

Boeing 720B:
American, 12; Avianca, 3; Continental, 8; El Al 2; Ethiopian, 3; Lufthansa, 8; Northwest, 17; PIA, 4; Pan-Am, 3; Saudi Arabian, 2; Western, 22.

SPECIFICATIONS

	Boeing 720B	Boeing 707-320B
Span:	130 ft. 10 ins.	145 ft. 8½ ins.
Length:	136 ft. 2 ins.	152 ft. 11 ins.
Height:	38 ft. 4 ins.	42 ft. 5 ins.
Power:	Four 17,000 pound thrust P & W JT3D-1.	Four 18,000 pound thrust P & W JT3D-3.
Max. Weight:	235,000 pounds.	332,000 pounds.
Passenger accommodation:	165	189
Max. Cruise Speed:	557 m.p.h. at 35,000 ft.	597 m.p.h. at 23,000 ft.
Max Range:	5,800 miles	8,070 miles



Pressure refuelling a Lufthansa 707 at Frankfurt International Airport. (Photo: Lufthansa)

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