AIRCRAFT ACCIDENT REPORT

JAPAN AIR LINES, LTD.,
DOUGLAS DC-8-33, JA-8006
San Francisco, California
December 25, 1965

Released:
July 15, 1967

Department of Transportation
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20591

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File No. A-0001

DEPARTMENT OF TRANSPORTATION
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SYNOPSIS

At 1308 P.s.t., December 25, 1965, Japan Air Lines Flight 813, a Douglas DC-8-33, JA-8006, departed the San Francisco, California International Airport for Tokyo, Japan. About 1311 at 4,500 feet in a scattered cloud condition there was an explosion in the No. 1 engine and fire broke out in the engine area. The fire was subsequently extinguished and the aircraft was landed safely at the Oakland, California International Airport. There were no injuries to the crew of 10 and 31 passengers; the aircraft was substantially damaged by the engine explosion and fire that followed.

The Board determines that the probable cause of this accident was a disintegrating engine failure and inflight fire caused by the failure of maintenance personnel to properly secure the low pressure compressor section torque ring during engine overhaul.

1. INVESTIGATION

1.1 History of the Flight

Japan Air Lines (JAL) Flight 813, of December 25, 1965, a Douglas DC-8-33, JA-8006, was a scheduled international passenger flight from the San Francisco, California International Airport to Tokyo, Japan, with an en route stop at Honolulu, Hawaii.

Flight preparations which included filing an Instrument Flight Rules (IFR) flight plan were made in a normal manner and at 1308 P.s.t. 1/ in a scattered cloud condition the flight departed Runway 01. Departure was in accordance with a standard instrument departure route. Aboard the aircraft were 10 crew-members and 31 passengers. Four of the latter were non-revenue.

About three minutes after takeoff the flight was proceeding under climb power at 4,500 feet at an airspeed of 270 knots over the South San Francisco area. At this time the crew felt and heard a muffled explosion and the aircraft yawed violently left and vibrated noticeably. At the same time all instrument indications for the No. 1 engine became erratic and the crew recognized that a major engine failure had occurred. Emergency procedures for engine failure were immediately executed and the aircraft vibration stopped.

The crew later stated that there was no fire warning when the emergency occurred. Because of this and the difficulty in viewing the No. 1 engine from the pilots' compartment they did not know a major fire existed in the No. 1 engine and wing area until, within 15 or 20 seconds, the purser and one of the non-revenue passengers ran forward and told them. Emergency procedures for

1/ All times are Pacific standard based on the 24-hour clock.

engine fire were executed and when fuel to the engine was turned off in this procedure the fire went out. A ground witness was taking motion pictures of the aircraft at this time. The film showed the fire go out and then the characteristic white puff of fire extinguisher discharge.

Just before 1312, within the first minute after the onset of the emergency, the flight radioed the emergency to San Francisco Departure Control requesting emergency equipment and immediate landing. Approval was given and the captain, who was flying the aircraft from the left seat position, began a return to land at San Francisco.

About the time the emergency was declared the captain advised his crew that he was having difficulty with lateral control of the aircraft. At this point, it was noted that the primary hydraulic pressure indication was fluctuating between 1200 and 1700 p.s.i., the hydraulic fluid quantity indication was decreasing and the aileron reversion light was coming on intermittently. [2/] With these indications of hydraulic failure [3/] the engine hydraulic pumps were turned off. The captain could not hold the left wing up with manual aileron, whereupon the auxiliary hydraulic pump was turned on and standby (emergency) rudder power was engaged. With this action, control was restored and the aileron reversion warning light stopped illuminating.

At 1316, because of the control difficulty experienced and to avoid a steep left turn to land at San Francisco International, the flight requested

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2/ Indicating hydraulic boost to aileron control was being lost, leaving manual control without hydraulic boost assistance.

3/ A piece of stator vane from the No. 1 engine had pierced the No. 2 engine pylon and ruptured a hydraulic line.

and was cleared to land on Runway 29 at the Oakland International Airport. Crash emergency measures were quickly taken at the Oakland Airport.

Although the captain experienced momentary aileron reversion to manual when the landing gear and flaps were extended, the latter limited to 25 degrees, he made a safe landing at 1320. The inboard engine ejectors had been extended by emergency air pressure, and through the use of maximum reverse thrust from the inboard engines and heavy braking, the aircraft was brought to a stop with about 1,800 feet of runway remaining.

The accident occurred under daylight conditions at a position approximately 122°26'W and 37°40'N.

1.2 Injuries to Personnel

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Nonfatal	0	0	0
None	10	31	

1.3 Damage to Aircraft

The aircraft received substantial damage. The No. 1 engine was disintegrated. The left wing, No. 2 engine pylon, and fuselage received shrapnel-type damage. The No. 1 engine pylon and the left wing structure from the leading to trailing edges in the area of the No. 1 engine sustained extensive fire damage.

1.4 Other Damage

No damage to other property.

1.5 Crew Information

Captain Tsuneo Kato, age 40, held airline transport pilot certificate No. 290, with airplane multi and single engine land, DC-8, CV-880, DC-7/6 and DC-4 ratings issued by the government of Japan. His last proficiency check was satisfactorily completed November 29, 1965. He held a first-class medical certificate with no limitations issued on November 1, 1965. He had flown 8,031 4/ total hours, of which 909 were in the DC-8. In the 90 days preceding the accident he had flown 189 hours, all in the DC-8.

Copilot Shinsuke Jinnaka, age 30, held commercial pilot certificate No. 947 with airplane multi and single engine land, DC-8, DC-7/6 and DC-4 ratings issued by the government of Japan. He held a first-class medical certificate with no limitations issued on November 1, 1965. Copilot Jinnaka had flown 1,768 hours of which 234 were in the DC-8. In the 90 days preceding the accident he had flown 168 hours, all in the DC-8.

Flight Engineer Harold L. Brown, age 41, held flight engineer certificate No. 49 with airplane multi engine, DC-8, DC-7/6 ratings issued by the government of Japan. He held a second-class medical certificate issued April 22, 1965, with no limitations. His last annual proficiency check was satisfactorily completed January 4, 1965. Flight Engineer Brown had accumulated 14,077 total hours of which 1,560 were in the DC-8. He had flown 144 hours during the 90 days preceding the accident, all in the DC-8.

Navigator Susumu Kohno, age 41, held first navigator certificate No. 20, and a radio operator certificate issued by the government of Japan. He held a first-class medical certificate with no limitations issued November 1, 1965.

4/ Flight hours are rounded to the nearest full hour.

His last annual proficiency check was satisfactorily completed April 13, 1965. Navigator Kohno had flown 7,305 total hours of which 2,715 were in the DC-8. In the 90 days preceding the accident he had flown 157 hours, all in the DC-8.

The first purser, the two stewards and three hostesses were regular employees of Japan Air Lines and the evacuation training of each was current.

All of the crewmembers had received a rest period of more than 24 hours preceding Flight 813 and had been on duty about 1:20 hours before the accident.

1.6 Aircraft Information

The aircraft, a Douglas DC-8-33, serial No. 45626, was manufactured with a completion date of May 2, 1961. It had accumulated a total of 13,423 hours, of which 21.5 were since the last major inspection. The aircraft was powered by four Pratt and Whitney JT4A-9 engines with engine histories as follows:

Position	Date of Manufacture	Serial No.	Total Hours	Hours Since Overhaul
1	3/15/60	611311	9835	21.5
2	3/26/60	611366	9656	2806
3	8/22/60	611711	8234	2294
4	4/4/60	611453	9043	2353

Investigation revealed that during August 1965, engine S/N 611311 was overhauled by Japan Air Lines at its Tokyo facility. It was installed in the No. 1 position on JA-8006 about November 20 during an overhaul of the aircraft. Post-overhaul test flights were accomplished and the aircraft was returned to scheduled service on December 24, 1965.

Engine overhaul records showed that during the course of the engine overhaul the low pressure compressor torque ring, P/N 310172, was found cracked and therefore replaced. The torque ring is located in the low pressure compressor at the area of the compressor case "C" flange adjacent to the fourth stage compressor stator assembly. 5/ It serves to prevent rotation of the compressor stators. In position, the ring is tightly fitted and a series of slots on the ring mate with a series of lugs on the outer diameter of the fourth stage stator shroud. By design the torque ring is secured in place by 90 rivets, P/N AN 13340, made of AMS 7232, a nickel base alloy. The design shear strength of each rivet is 16,000 p.s.i. at 350 degrees, C. The ring is riveted to the compressor case "C" flange.

There are three borescope inspection ports in the outer compressor case and stator outer shroud. Each of the ports is closed by a threaded plug. Though not designed for the purpose, the ports and plugs tend to impede rotation of the compressor stator assembly.

Company maintenance personnel involved in the engine overhaul and installation of the new torque ring stated that a new ring was drawn out of the maintenance parts department. They described how it was fitted into the engine and that when it was properly in place the necessary rivet holes were drilled in the ring to align with the rivet holes already in the compressor case adjacent to the "C" flange. According to the statements, rivets were pushed into the holes and secured with paper tape. A mechanic then went into the engine case section and riveted the torque ring in place. The mechanics involved stated that the rivets used in the work were not drawn from the stock room, as they

5/ See Attachment I, "Explanatory Diagram."

normally would be, but rather they used rivets left over from other jobs. At least one mechanic said he thought he saw the rivets for the work taken from a yellow bag.

A review of the company stock records showed that a new torque ring had been issued for installation in the engine under a parts request slip. There was no record to indicate the necessary rivets had been issued. Normally 100 rivets contained in a yellow bag would be issued and a record of the issue would be made.

For Flight 813, the aircraft was serviced to a total fuel load of 108,000 pounds of Jet A turbine fuel. At takeoff the gross weight of the aircraft was 259,330 pounds. The maximum allowable was 288,600 pounds. The center of gravity (c.g.) of the aircraft was 27.6 percent Mean Aerodynamic Chord, within c.g. limitations.

1.7 Meteorological Information

At the time and place of the accident weather conditions were: scattered clouds at 4,500 feet; visibility 50 miles; wind 280 degrees, 10 knots.

1.8 Aids to Navigation

Not involved.

1.9 Communications

Communications equipment functioned normally.

1.10 Aerodrome and Ground Facilities

The Oakland International Airport, where the emergency landing was made, is located 10 miles northeast of the San Francisco International Airport from which the flight departed. Runway 29, used for the landing, is 10,000 feet long, of part concrete and part asphalt construction and at the time of landing the surface was dry. No other aerodrome or ground facilities were pertinent to the accident.

1.11 Flight Recorders

A flight recorder was not required in the aircraft by the government of Japan; however, a simplified spool type was installed. The only information it provided, vertical acceleration, was not pertinent to this accident.

1.12 Wreckage (Damage)

The major damage sustained by the aircraft was to its No. 1 engine and pylon, and to the left wing from the leading to trailing edges in the area generally aligned with the No. 1 engine. The principal engine damage was the type associated with a disintegrating engine failure. The engine pylon and wing damage was mainly from intense fire although both received shrapnel-like penetrations from flying engine pieces. Flying pieces made two punctures in the fuselage and as previously noted one piece of stator vane penetrated the No. 2 engine pylon and ruptured a hydraulic line. Twelve other pieces pierced the No. 2 engine pylon and one or more of these severed the No. 2 engine thrust reverser pneumatic retract line.

Investigation revealed that the No. 1 engine low pressure compressor outer case had shattered into many pieces and separated from the engine. The forward portions of the engine cowl doors were torn away and the air inlet case had separated from the engine, exposing the low pressure compressor. All stages of the compressor were damaged, with compressor blades bent, torn and broken in the direction opposite to rotation. All stages of stator vanes were dislodged from the compressor.

The starter, generator, and constant speed drive of the engine were broken from the lower accessory gear box. The oil tank was separated from its mount and punctured by flying engine pieces.

Through a search of the Brisbane - South San Francisco area where parts from the aircraft were reported to have fallen, about 100 pieces from the No. 1 engine were recovered. One piece, 30 inches by 8 inches with a 40-inch strip attached, was a segment of the low compressor outer case from the rear of the compressor case "C" flange at the No. 4 stage stator position. The strip and forward edge of the piece showed frictional heat discoloration. The strip also exhibited extensive circumferential scoring on its inside diameter in the area of the fourth stage stator outer shroud.

Among the recovered pieces there were two other segments of the low compressor case "C" flange, one 75 inches long and the other 12 inches long. Both pieces showed frictional heat discoloration at the rear area of the flange, and in the same area the flange was separated circumferentially from the compressor case. Along the line of separation the metal was molten in appearance. In portions of this area there were a number of rivet holes for the purpose of riveting the torque ring in place. On the forward side of the pieces of "C" flange small pieces of compressor case were still attached and the fracture side of the pieces evidenced tearing type separation.

The rear flange of the compressor case remained attached to the intermediate case and a piece of low compressor case 35 inches by 18 inches was attached at the 7 o'clock location. The latter piece was heavily scored on the inside diameter and the shroud support showed frictional heat discoloration.

The borescope inspection plug hole boss at the seventh stage stator 9 o'clock position was deformed and scored in the direction of compressor rotation. 6/

During the course of the search for engine parts no portion of the low pressure compressor torque ring was found.

Fire damage to the left wing was in a swath-like pattern from the leading edge rearward to the trailing edge, approximately the width of the No. 1 engine. The No. 1 pylon skin was nearly burned away. There was a hole about 12 inches by 10 inches burned through the de-icing duct area at the leading edge of the wing, and there were chordwise fire stains on both the upper and lower wing skin surfaces just outboard of the engine pylon. The wing rear spar caps and web showed evidence of heat exposure. The wing lower trailing edge panels outboard of the No. 1 pylon were burned, as were the upper trailing edge panels. The latter burn area was from inboard of the outboard flap to the inboard side of the outboard aileron. The inboard aileron and tab outboard of the No. 1 pylon were about 50 percent destroyed by fire and the aileron was warped upward.

1.13 Fire

The No. 1 engine fuel line pylon-to-engine quick disconnect was separated and the locking lugs on the engine side of the disconnect were sheared off.

6/ Portions of the pieces hereinbefore described were given laboratory metallurgical examination. See Section 1.15, Tests and Research.

The pylon side of the disconnect valve was found jammed in the open position. A fire damage pattern orginated from this valve.

Examination revealed the No. 1 engine emergency fuel shutoff valve located behind the fire wall at the top of the engine pylon was in the off position.

The No. 1 engine fire warning system was found inoperative. Investigation showed that with separation of the forward portion of the engine nacelle doors the fire warning loop was disrupted. The loop at the rear or hot section of the engine was intact but a connector was torn out with the cowling.

Examination of the fire extinguisher system showed normal operating capability. The No. 1 extinguisher container was empty. Containers Nos. 2, 3, and 4 were full.

1.14 Survival Aspects

Cabin crew personnel reported that during the emergency the passengers were calm. Emergency landing instructions were issued. Each passenger was given a pillow and blanket while seat belts were tightened and checked by a cabin attendant. After the landing all exits on the right side were opened. Passenger evacuation was made using slide chutes from the right forward and aft service doors.

Emergency rescue and fire equipment of the Oakland International Airport, having been alerted, converged on the aircraft from strategic positions beside the runway. The No. 1 engine was washed down to assure no fire threat existed and dry chemical was put on the brakes which were extremely hot from heavy braking.

1.15 Tests and Research

Two pieces of the low pressure compressor case, one with an area of rivet holes used in riveting the torque ring in place, and one piece of the fourth stage stator vane assembly, were given laboratory examination. Examination of the two pieces of compressor case showed severe rotational abrasion, and associated high temperature had occurred in the section of the case that normally mates with the low pressure compressor torque ring. No corresponding evidence of abrasion and high temperature was found on the lugs of the piece of fourth stage stator vane assembly that mate with the slots in the torque ring.

The examination revealed no fragments of metal that could be identified as from the torque ring. It was noted, however, that both the torque ring and the compressor case "C" flange were fabricated from the same material, AMS 6280 steel.

A visual and spectrochemical examination of samples of all pieces revealed no evidence of rivet material in the abrasion and heat damage areas on the pieces from between the case "C" flange and torque ring. It was noted that the dissimilar metal composition of these components and the rivets would have made rivet material readily identifiable under spectrochemical examination. The rivet holes in the case piece did not show any evidence of elongation in the direction of compressor rotation.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

From the evidence obtained during the investigation of this accident it was established that the preparations for Flight 813 were complete and conducted in a routine manner. All of the crewmembers were well qualified and properly certificated for the operation. The aircraft was properly loaded at a gross takeoff weight of 259,330 pounds and the flight originated on time at 1308 with takeoff from Runway 01 of the San Francisco International Airport. Weather conditions were nearly clear and thus presented no adverse factor in the accident sequence which followed.

Takeoff was normal and the flight continued to progress in a routine manner until about three minutes after takeoff when it was proceeding under climb power about 4,500 feet over the South San Francisco area. At this time there was a disintegrating engine failure of the No. 1 engine and fire broke out in the No. 1 engine, pylon and associated wing area. At the same time a progressive hydraulic failure started.

The crewmembers under the command of the captain responded to the emergency conditions with emergency procedures for engine failure, engine fire and hydraulic failure in that order. The prompt efficiency of the crew is reflected by the times of certain radio messages. These showed that between the first emergency radio call until the one advising the fire was out little more than one minute elapsed.

Still experiencing some lateral control difficulty due to the loss of hydraulic efficiency and apparently to reduced effectiveness of the left inboard aileron caused by fire damage and deformation, the captain elected to divert the flight to the Oakland International Airport. At 1320, about nine minutes after the onset of the emergency, he made a safe landing.

From the physical evidence obtained in the investigation and from crew information it was clearly established that the inflight fire, the absence of cockpit fire warning, the hydraulic problem and all damage were direct results of the disintegrating failure of the No. 1 engine. There was no other malfunction or failure of the aircraft of a causal nature involved.

The force of the engine breakup was shown to have separated the quick disconnect valve in the pylon to engine fuel line and the force so damaged the valve that it remained in the open position. Fuel was thereby released into the engine and ignited. Because the separation was upstream of the engine fuel control,the fuel flow was not stopped by the engine shut-down procedures. Consequently, the fire continued until the cockpit control for the emergency fuel shutoff valve was actuated in the emergency fire procedure and the valve, located upstream of the quick disconnect, closed, thus stopping the fuel flow. A motion picture being taken of the flight by a ground witness furnished the evidence which established that the fire went out with this action and before the engine fire extinguisher was discharged. In this regard the movie showed the fire disappear and then the white puff of the extinguisher being discharged.

The fire warning system failed to function because the same disintegrating force tore away the sensor portion of the system. The hydraulic system problem was caused by a piece of stator vane from the No. 1 engine which pierced the No. 2 engine pylon and ruptured a hydraulic line.

Since no rivet material was found and the rivet holes in the area of damage were not elongated, the Board concludes that the low pressure compressor torque ring designed to prevent rotation of the low pressure compressor stator assembly was not secured in place by riveting during overhaul of the engine. As a result, when the restraining effect of the tight fit of the ring and the three borescope inspection port plugs was overcome by the normal rotational forces within the compressor, the stator assembly and torque ring began to turn.

At high rotational speed the torque ring bearing on the low pressure compressor case literally ground through the case until the case was so weakened that it disintegrated with explosive force. This is clearly sustained by the extreme abrasive and heat damage found on the recovered pieces of compressor case and stator vane assembly which came from the precise location where the torque ring would make contact.

Because no part of the torque ring was found and none of its metal could be identified in the damage area, the Board considered the possibility that the torque ring itself was not installed. This was dismissed on the overall evidence. Had the torque ring not been in position, the lugs on the outer diameter of the fourth stage stator shroud would have been exposed rather than protected by the mating slots of the torque ring. Assuming such a situation, the lugs would have received the same abrasive and heat damage sustained by the unexposed parts. They did not show this damage; therefore, they were protected and only the torque ring could have furnished the protection. It is also reasoned that metal from the ring was not identified in the areas of extreme abrasion and heat damage because the parts subjected to the damage were fabricated from the same material. Finally, it is not unusual that none of the torque ring was recovered, since by the time it had ground through the compressor case there would have been little of it remaining.

2.2 Conclusions

(a) Findings:

1. The flight crew was properly certificated and qualified for the flight operation.
2. Preparations for the flight were routine and it was dispatched in accordance with regulatory and company requirements.
3. About three minutes after takeoff a disintegrating engine failure occurred, followed by an inflight fire and partial hydraulic failure.
4. Emergency procedures for engine failure, engine fire and hydraulic failure were executed quickly and efficiently.
5. When the emergency fuel shutoff valve was closed during the emergency fire procedure the fire went out.
6. The captain diverted the flight to the Oakland International Airport and made a safe landing.
7. Cabin emergency landing procedures were complete and efficient, as were airport aircraft emergency ground procedures.
8. The engine failure was the result of the low pressure compressor torque ring not being secured in place by riveting during engine overhaul.

9. The inflight fire, lack of fire warning to the crew and the hydraulic difficulty were direct results of the engine failure.

10. The normal tight fit of the torque ring and restraining effect of the borescope inspection port plugs kept the torque ring in place during the time between the engine overhaul and the engine failure.

11. Weather was no factor in the accident.

(b) Probable Cause

The Board determines that the probable cause of this accident was a disintegrating engine failure and inflight fire caused by the failure of maintenance personnel to properly secure the low pressure compressor section torque ring during engine overhaul.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOSEPH J. O'CONNELL, Jr.
Chairman

/s/ OSCAR M. LAUREL
Member

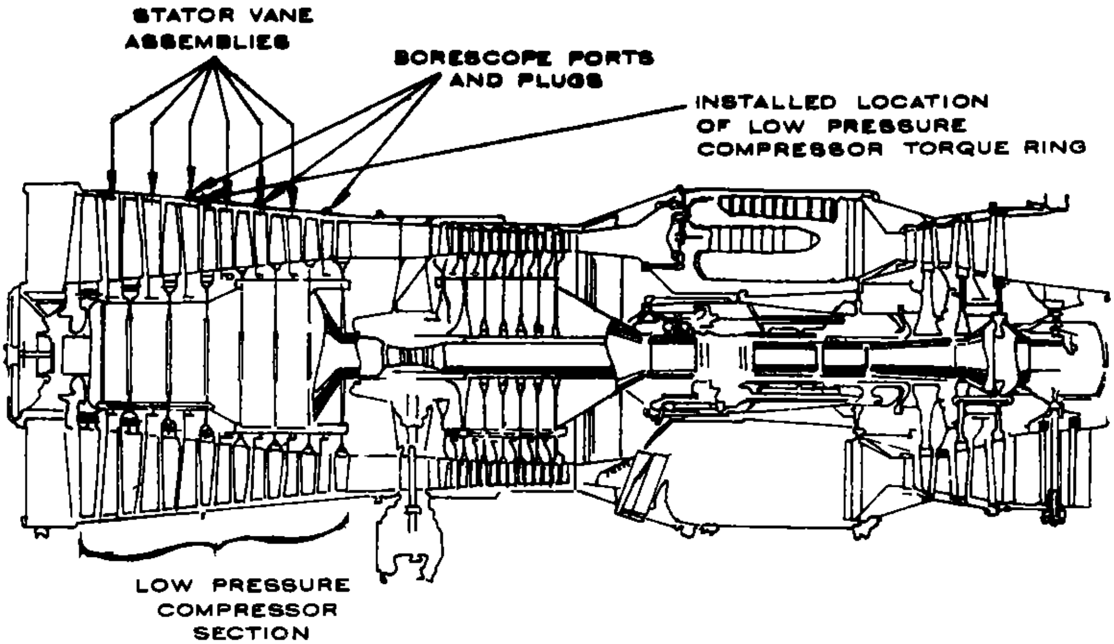
/s/ JOHN H. REED
Member

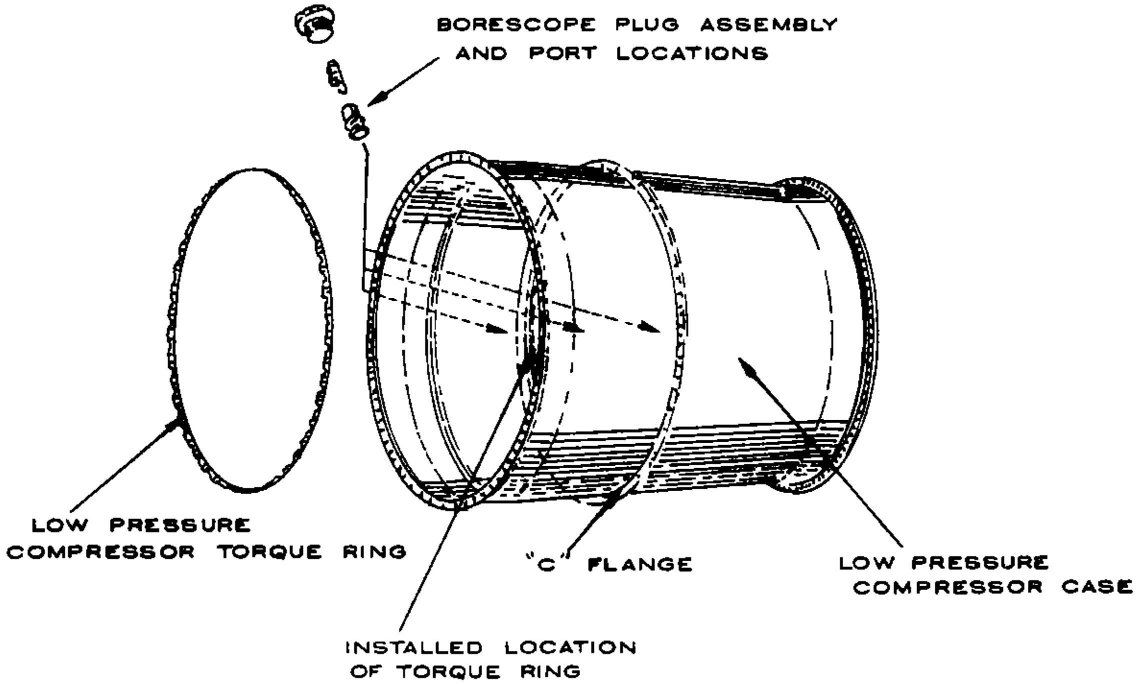
/s/ LOUIS M. THAYER
Member

/s/ FRANCIS H. McADAMS
Member

EXPLANATORY DIAGRAM

JT4 A-9 ENGINE





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