

PB88-910405



# **NATIONAL TRANSPORTATION SAFETY BOARD**

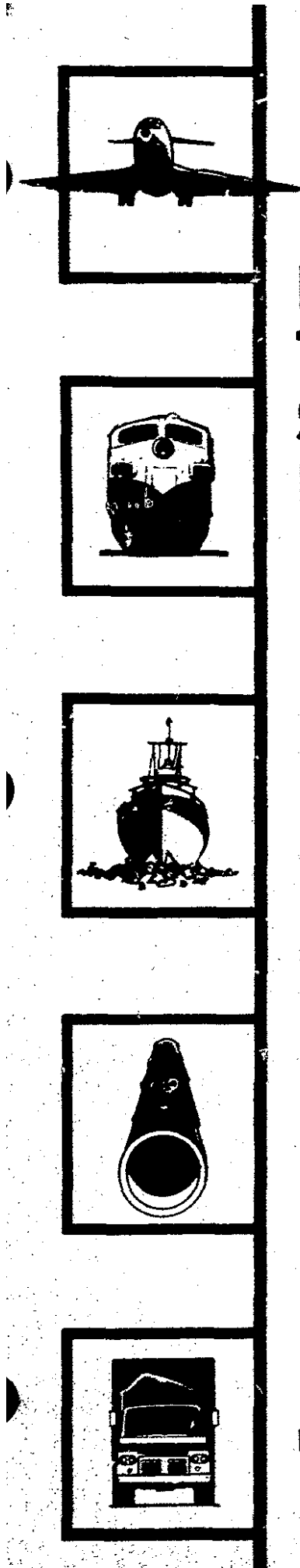
WASHINGTON, D.C. 20594

## **AIRCRAFT ACCIDENT REPORT**

**JOE FOSTER EXCAVATING, INC.,  
BELL206B, N49606,  
IN-FLIGHT COLLISION WITH TREES,  
ALAMO, CALIFORNIA  
AUGUST 3, 1986**

NTSB/AAR-88/04

**UNITED STATES GOVERNMENT**



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## **EXECUTIVE SUMMARY**

On August 3, 1986, at 1235 Pacific daylight time, a Bell 206B helicopter, N49606, owned and operated by Joe Foster Excavating, Inc., Danville, California, crashed in a wooded area in Alamo, California, while circling a residence. Visual meteorological conditions prevailed at the time. The pilot and passenger, the owner of the helicopter, sustained fatal injuries; the helicopter was destroyed.

The safety issues addressed in this report concern the ability of pilots to secure medical certification despite potentially incapacitating diseases, the Federal Aviation Administration's special-issuance medical certificate practices, and the Federal Air Surgeon's disregarding of other medical recommendations concerning medical certificate applications and procedures in medically recertifying the pilot.

The National Transportation Safety Board determines that the probable cause of this accident was the pilot's incapacitation resulting from a myocardial event. Contributing to the cause of the accident was the pilot's failure to comply with the provisions of both his medical and pilot certificates and the inadequate procedures used by the Federal Air Surgeon to medically recertify the pilot.

As a result of its investigation, the Safety Board issued recommendations to the Federal Aviation Administration to require that persons applying for special-issuance medical certificates under the provisions of Title 14 Code of Federal Regulations 67.19 provide evidence that any requested cardiovascular evaluations were performed by a physician certified by the American Board of Cardiology and that a recognized standard protocol was used in any related stress electrocardiogram examination.

In addition, the Safety Board recommended that the Federal Aviation Administration institute procedures and associated record keeping to show that the Federal Air Surgeon or a medical consultant(s), at least one of whom is recognized and certified in the medical discipline under consideration, review all treating physician(s) diagnosis before issuing a medical certificate under the provisions of Title 14 Code of Federal Regulations 67.19.

# NATIONAL TRANSPORTATION SAFETY BOARD WASHINGTON, D.C. 20594

## AIRCRAFT ACCIDENT REPORT

JOE FOSTER EXCAVATING, INC.  
BELL 206B, N49606  
IN-FLIGHT COLLISION WITH TREES  
ALAMO, CALIFORNIA  
AUGUST 3, 1986

### 1. INVESTIGATION

#### 1.1 History of the Flight

On August 3, 1986, at 1130 Pacific daylight time, a Bell 206B helicopter, N49606, departed Livermore Airport, Livermore, California, with the pilot and one passenger aboard. The flight was scheduled to fly near Danville, California, and then to continue to Discovery Bay, near Antioch, California. The flight was conducted under Title 14 Code of Federal Regulations Part 91 visual flight rules. The pilot did not file a flight plan nor was he required to.

At 1150, the helicopter landed at a ranch near Danville. The pilot remained seated in the right front seat of the helicopter, while the passenger deplaned and visited with friends. The passenger told the ranch owner that he intended to fly over a mutual friend's residence at Alamo and continue to Discovery Bay. The helicopter departed the ranch at 1220 hours with the passenger.

Ground witnesses reported that the helicopter approached the residence in Alamo from the west at 50 feet above ground level<sup>1/</sup>. When the helicopter was over the residence, it entered into a 20°-left banking turn and completed two turns. When beginning the third turn, the helicopter entered into an abrupt 90°-left bank, pitched downward about 45°, and crashed into the trees. Witnesses stated that it sounded like a cannon explosion when the main rotor blades struck the trees. There was no postimpact fire. All the witnesses reported that the engine and rotor systems sounded normal and steady throughout the accident sequence.

The helicopter crashed at 37°51'58" N latitude and 122°01'04" W longitude.

#### 1.2 Injuries

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	<u>Total</u>
Fatal	1	1	2
Serious	0	0	0
Minor	0	0	0
None	0	0	0
Total	1	1	2

<sup>1/</sup> All altitudes, unless otherwise noted, are above ground level (agl).

### **1.3 Damage to Aircraft**

The helicopter was destroyed. The hull loss value of the helicopter was \$250,000.

### **1.4 Other Damage**

One oak tree sustained substantial damage.

### **1.5 Personnel Information**

The pilot was hired by Joe Foster Excavating, Inc., on July 15, 1986. The executive vice president of the company stated that all new employees are required to submit to a preemployment physical examination as a condition of employment. The pilot, however, was not required to take the examination because he had recently been issued a second-class medical certificate by the Federal Aviation Administration (FAA).

The pilot, 49, weighed 220 pounds and was 6 feet 3 inches tall. The Safety Board could not determine the medical history of the pilot's family.

The pilot held an airline transport pilot certificate with an airplane single-engine land rating; the certificate was endorsed for commercial pilot privileges in airplane multiengine land and rotorcraft-helicopter. Safety Board investigators did not recover the pilot's flight hours logbook; therefore, it could not be determined if the pilot had complied with the biennial flight review or general recency requirements of 14 CFR 61.57(a)(1), (2), and (c).

The Safety Board recovered the pilot's resume which had been given to the insurers of Joe Foster Excavating, Inc. The pilot's resume indicated that he had accrued 16,272 total flight hours as of May 15, 1985, of which 5,110 flight hours were flown in helicopters. The pilot's actual flight time in the accident helicopter make and model could not be determined. The pilot successfully completed the 206B helicopter orientation training at the helicopter Training Center, Fort Worth, Texas, on December 17 through 19, 1980.

FAA records revealed the pilot had received the rotorcraft-helicopter rating on August 17, 1968.

Between 1980 and 1985, the pilot was employed periodically by Pan Fisheries, Inc., San Pedro, California, as a fish spotter. His duties required him to fly helicopters from a tuna boat.

The Safety Board reviewed the pilot's certification history and found that the pilot paid civil penalties to the FAA in a compromise settlement for two Federal Aviation Regulation (FAR) violations. The violations occurred from two separate incidents—fuel exhaustion while conducting an air taxi flight and low flying over persons in the surf.

On August 4, 1986, the FAA's, Oakland Flight Standards District Office received a report that the accident helicopter was flying "dangerously low" over some boats at Discovery Bay on August 2, 1986. The executive vice president stated that the pilot was flying in N49606 with the owner on that day; however, he did not know the flight's itinerary. The accident helicopter was flown exclusively by the pilot.

#### **1.5.1 Pilot's Medical Treatment**

On October 6, 1981, the pilot consulted a cardiologist (herein referred to as his treating physician) about a previously diagnosed irregular arrhythmia-atrial fibrillation. (See appendix C for a more complete explanation of medical terms contained in this report.) The Safety Board could not

determine who originally diagnosed his atrial fibrillation. The treating physician prescribed digoxin medication and admonished the pilot to stop drinking and smoking.

On October 10, 1981, the treating physician examined the pilot and noted that the medication was unsuccessful in controlling the atrial fibrillation. The pilot reported that he continued to drink and smoke, but that "he had tapered off." The treating physician recommended electrical cardioversion; but the pilot declined. The treating physician continued with the digoxin medication.

The treating physician reported he again saw the pilot in May 1982 and that the pilot remained in atrial fibrillation. The pilot said that he was still working as a helicopter pilot on a fishing boat, that he "drank heavily" while in port, and that he had stopped using the prescribed medication. The pilot again declined electrical cardioversion, and the treating physician continued to prescribe the digoxin medication.

In September 1982, the treating physician changed the pilot's medication to quinidine and ordered an echocardiogram; the echocardiogram was unremarkable. The medication was unsuccessful in controlling the atrial fibrillation.

On October 6, 1982, the pilot underwent electrical cardioversion at St. John's Hospital, Oxnard, California. The electrical cardioversion did not return his heart to a normal rhythm. The pilot still continued to drink and smoke.

In January 1983, the treating physician advised the pilot that the doctors at the University of California, Los Angeles (UCLA) recommended against the use of experimental drugs to convert his atrial arrhythmia. The treating physician reported that "symptomatically he [the pilot] was fine; he had no particular awareness of the abnormal heart rhythm."

On May 7, 1986, the pilot experienced chest pains and went to St. John's Hospital emergency room for treatment. His treating physician administered an at-rest electrocardiogram (EKG); the EKG was unremarkable. However, while the pilot was in the screener bed, he developed ventricular fibrillation (myocardial infarction). The treating physician resuscitated the pilot from this episode. The pilot was taken to the cardiac catheterization laboratory and a coronary angiogram was performed.

The treating physician admitted the pilot in the hospital and placed him in the intensive care unit with the following diagnosis: acute lateral myocardial infarction; ventricular fibrillation; and chronic atrial fibrillation. The treating physician discharged the pilot from the hospital on May 14, 1986.

In the pilot's discharge diagnosis, the treating physician stated the coronary angiography disclosed, in part:

... an occlusion of a small to moderate sized marginal branch of the circumflex artery, diffuse irregularity with minimal narrowing of the proximal right coronary artery and a 70 percent stenosis of the distal right coronary artery.

On May 30, 1986, the treating physician did a stress EKG on the pilot using the Bruce protocol. The pilot achieved the third stage, but he could not continue to the fourth stage due to generalized fatigue. The EKG showed rare premature ventricular contractions, two ventricular contractions, two ventricular couplets, and nondiagnostic abnormalities of the ST segment. The treating physician interpreted the EKG as "negative for ischemia." He instructed the pilot to "increase his activity" and to return to his office in 3 weeks for a routine follow-up examination; the pilot never returned.

## **1.5.2 Pilot's Chronological FAA Medical Certification Summary**

### **December 1980**

An FAA-designated Airman Medical Examiner (AME) issued a second-class medical certificate to the pilot; this was the last certificate issued to the pilot until January 28, 1985. There is no record that the pilot applied for a medical certificate after December 1980 and before January 26, 1984.

### **January 26, 1984**

The pilot retained another FAA AME at the Center for Heart and Health (see appendix B), a rehabilitation clinic, for a coronary evaluation. The AME, who is not a board-certified cardiologist, administered an exercise EKG using his own protocol. The results of the EKG required the pilot to undergo a coronary angiogram.

The AME noted on the pilot's medical history report that the pilot consumes a modest amount of alcohol 5 to 6 days per week, smokes about a half pack of cigarettes per day (he started smoking at age 15), and drinks about 4 to 5 cups of caffeinated beverages per day. He also noted that the pilot regularly walks or jogs about 1 to 2 miles daily. The AME advised the pilot to avoid any alcoholic beverages, to avoid sugar/refined carbohydrates, to quit smoking, and to lose weight.

### **January 27, 1984**

A cardiologist at the Daniel Freeman Hospital, Inglewood, California, performed a coronary angiography on the pilot. The physician reported, in part:

This patient has moderate distal right coronary artery disease with a 50 percent narrowing before the take-off of the posterior descending artery which is the main distal branch. The left anterior descending branch has a 20-30 percent narrowing proximally and a 20 percent narrowing at its midportion. There is a small posterolateral branch, as well, which has a mild 20 percent narrowing. The remainder of the circumflex vessel and the a/v groove is a dominant vessel which is free of disease.

The left ventricle at rest displays anteroseptal wall hypokinesis. The remaining myocardium functions within normal limits. Following the ingestion of oral nitroglycerin, there is improved function of the anteroseptal wall which remains slightly hypocontractile and continuous normal function of the remainder of the ventricle. A mild mitral valve prolapse is accentuated following the ingestion of nitrates. The left ventricular end diastolic pressure was at the upper limits of normal at rest and reduced to within normal limits following the ingestion of nitroglycerin.

In a letter to the FAA's Aeromedical Standards division manager, Washington, D.C., the AME recommended that the FAA issue the pilot a special-issuance second-class medical certificate. The letter was written on the Center for Heart and Health stationery.

### **June 7-8, 1984**

The FAA medical consulting panel, which included three board-certified cardiologists, recommended in a prepared working paper that "the airman's request for airman medical certification be denied."



The following, in part, are the medical findings and recommendation of the consulting panel:

The consultants review[ed] the case of [the pilot]. They noted he has had atrial fibrillation for the past several years and repeat[ed] attempts to convert his arrhythmia both electrically and medically have been unsuccessful. His current cardiovascular reveals ST changes on electrocardiogram with both hyperventilation and exercise. The consultants reviewed the actual tracings of his electrocardiogram and commented that there was [a] 2-millimeter ST segment depression present.

The films of his cardiac catheterization were reviewed and revealed the presence of septal hypokinesis and his ventriculogram revealed poor left ventricular function. There was minimal coronary disease present; however, in their opinion, there is 50 percent occlusion of the posterior descending branch of the coronary tree.

When the consultants completed their review, they expressed concern regarding the presence of atrial fibrillation in this case and the possibility of known complications of interference with ventricular function, including the possibility of a too rapid or too slow ventricular response (also known embolization) resulting from fibrillation of the atrial cavity.

In addition, the consultants detected evidence of early coronary artery disease and also the suggestion of an early cardiomyopathy. Therefore, they recommended that the airman's request for airman medical certification be denied.

#### September 24, 1984

Based on the consulting panel's "working paper," the then Federal Air Surgeon (FAS) denied the airman's request for certification. The Deputy FAS signed the letter.

#### October 1984

The FAA Administrator appointed a new FAS.

#### December 1984

The pilot met with the newly appointed FAS at his office in Washington, D.C., and he received assurance that the FAS would review his second-class medical certificate application.

#### January 28, 1985

The FAS issued the pilot a special-issuance second-class medical certificate that contained a "not valid for pilot-in-command (PIC) duties" restriction; he was also issued an unrestricted third-class medical certificate; the FAS did not require the pilot to undergo any other medical examinations.

#### August 27, 1985

The aeromedical certification branch manager, Civil Aeromedical Institute (CAMI), Oklahoma City, Oklahoma, sent the pilot a letter stating that the pilot was eligible for continued medical certification. He reminded the pilot that his current medical certificate would expire on January 31, 1986, and requested the following reports:

Cardiac examination by an internist or cardiologist [emphasis added] to include medical history as to symptoms or treatment referable to cardiovascular system;

general physical examination to include blood pressure, weight, funduscopic and cardiac examination, treadmill electrocardiogram tracings (unless medically contraindicated); and report of blood (cholesterol) (lipids).

**September 18, 1985**

In a letter to the FAS, the pilot thanked the FAS for getting him "legally, back in the air again." He also requested that the restriction, not valid for PIC, "be lifted."

**October 2, 1985**

The FAS telexed the aeromedical certification branch manager, CAMI, and instructed him to remove the pilot's second-class medical certificate limitation and issue him an unrestricted certificate if the "followup reports, due January 1986, are favorable."

**April 2, 1986**

The AME reevaluated the pilot and administered another stress EKG; again, the AME used his own protocol for the stress test.

**April 15, 1986**

The AME sent a letter to the aeromedical certification branch manager, CAMI, recommending that the pilot be granted an unrestricted second-class medical certificate. The branch manager forwarded the letter to the FAS.

**May 5, 1986**

The aeromedical certification branch manager issued the pilot a second-class medical certificate valid for only 12 calendar months; the certificate did not contain the "not valid for PIC" restriction. In the letter the manager stated, in part:

The decision to find you eligible for second-class medical certification, under Part 67.19 of the FAA Regulations, is in coordination with and authorized by the FAS....

...You must [emphasis added] remain under medical surveillance and must report any adverse change [emphasis added] in your medical condition to this agency. In such event, you must cease all flying activities [emphasis added] until you are again cleared by the Federal Aviation Administration....

The manager stated that the FAS instructed him in a telex communicate to reinstate the pilot. A "consults support" notation was included in the telex.

## **1.6 Aircraft Information**

The helicopter was purchased by the Joe Foster Excavating Company, Incorporated, on July 15, 1986. The helicopter was maintained under the annual inspection provisions of the FARs and in accordance with the Bell Helicopter recommended inspection schedules. The last annual inspection was performed on March 3, 1986, at a total time of 8,933.5 hours. A 25-hour inspection was performed on July 28, 1986, at a total time of 8,994 hours. The helicopter had accrued 9,019 hours at the time of the accident.

The helicopter was maintained in accordance with current applicable FARs.

## **1.7 Meteorological Information**

Visual meteorological conditions prevailed at the time of the accident. There is no official surface weather reporting facility at the accident site. Witnesses reported that the sky was clear with unlimited visibility. The surface winds were calm and the temperature was about 85° F.

## **1.8 Aids to Navigation**

Not applicable.

## **1.9 Communications**

There were no known communications between the helicopter and any ground facility.

## **1.10 Aerodrome and Ground Facilities**

Not applicable.

## **1.11 Flight Recorders**

The helicopter was not equipped nor was it required to be equipped with a cockpit voice recorder or a flight data recorder.

## **1.12 Wreckage and Impact Information**

The helicopter crashed about 300 feet south of the residence it was circling at an elevation of about 500 feet mean sea level (msl). The terrain at the crash site was hilly and sloped downward about 30°. The helicopter impacted an oak tree about 104 feet west of the main wreckage area. The elevation at the site was about 540 feet msl, and the height of the tree is about 35 feet agl. The observations of the witnesses, the rotor blade marks on the tree, and the wreckage examination disclosed the helicopter main rotor blades struck the tree while in a steep left-bank and nose-down attitude.

After initial ground contact, the helicopter continued down the slope until it collided with a gully at the bottom of the hill. The helicopter came to rest on its left side in a nearly inverted attitude on a 004°-magnetic heading. There was numerous plastic windshield and fuselage sheet metal debris at the initial ground impact area. Scattered helicopter debris was found throughout the ground path.

### **1.12.1 Airframe and Engine Examination**

**Airframe Examination.**--All of the flight controls and helicopter components were found at the accident site. The main rotor assembly separated from the rotor mast and was found beneath the main wreckage. The main rotor assembly components (the main rotor blades, both grips, and the hub assembly) were intact. Both blades sustained extreme impact/postimpact damage and displayed extensive leading edge gouging and chordwise scuff marks; the blades were impinged with extensive oak tree wood shavings.

Continuity of the transmission assembly to the output drive shaft was established. The transmission remained attached at its mounting brackets, but the transmission deck was torn away from the fuselage.

All of the power boost servos remained attached at their mounting brackets, and their push-pull tubes had separated. The servos functioned normally when hydraulic pressure was applied.

The fuselage bladder fuel tank had ruptured. The airframe fuel filter contained about 1/2 ounce of fuel. The fuel contained minor foreign debris and was free of any water.

Continuity of the tail rotor drive was established to the fractured end. The 90°-gear box was attached to its mounting bracket. The gear box rotated freely; the oil had drained out of the filler cap.

The tail rotor assembly was intact and attached to the 90°-gear box output drive. The tail rotor blades' leading edges showed no rotational scoring or chordwise scuffing signatures.

The cockpit/cabin area was destroyed. All of the seatbelts and shoulder harnesses remained attached at their respective attach points.

Both cyclic push-pull tubes remained attached at the lower uniball attach point. The upper end of the tubes were fractured and the fractured surfaces displayed overload characteristics. The collective push-pull tube separated at the eyeball connecting point.

Engine Examination.--Safety Board investigators examined the engine at National Airmotive Corporation, Oakland, California, on August 7, 1986. The engine was intact and exhibited extensive ground impact damage to its exhaust system. Continuity of the rotating components was established.

The compressor assembly housing displayed numerous ruptures around the case housing. The right-hand side ruptures (2) exhibited outward bulging signatures; the left-hand side showed an impact indentation beginning at the 12 o'clock position. The front support mount exhibited compression buckling signatures at the 12 o'clock position.

Both exhaust transfer tubes exhibited compression buckling signatures; the right hand duct at midspan was punctured; the area around the puncture displayed intense heat discoloration marks. Both upper exhaust collector ducts were crushed toward the engine casing.

The outer combustion case rear section was crushed inward. There were numerous metal shavings found in the housing. The rear section of the heat shield displayed numerous aluminum metallization and sooty signatures.

The compressor was disassembled. The rotor blades and vanes exhibited extreme rotor blade destruction between the second and third-stages. The first-stage rotor blade showed minor leading/trailing edge damage. The second- and third-stage rotor blades were completely severed. The fourth-stage rotor blades showed extensive leading/trailing edge damage. The fifth-stage rotor blades showed moderate leading edge damage. The sixth-stage rotor blades displayed minor leading edge damage and the seventh-stage showed no apparent damage. The impeller housing showed numerous rotational scoring signatures.

The compressor diffuser vane assembly sustained impact damage and numerous aluminum shavings, similar to the impeller housing material, were observed on the face side.

The first- and second-stage turbine wheel blades (N<sub>1</sub>) were intact and not damaged; the blades were impinged with many metal deposits. The second-stage turbine wheel balance piston contained numerous compressor blade shavings. The first-stage nozzle vanes contained many metallization deposits.

The third- and fourth-stage turbine wheels (N<sub>2</sub>) contained extensive amounts of metal and wood shaving particles. The turbine cooling air outer fourth-stage nozzle shroud contained extensive compressor lining deposits. The turbine blades were not damaged. The uppergear box magnetic chip plug contained one minor metal particle; the lower gearbox magnetic chip plug was free of any metal particles.

The system oil pressure filter was free of any contaminants. The number 8 bearing sump was intact and did not leak when 50 pounds of air pressure was applied. The oil pressure inlet line was severed at the base of the housing. The bearing rotated freely, but imminent dragging of the bearing surface was felt. There was no evidence of any extreme high temperature distress.

### 1.13 Medical and Pathological Information

The results of the postmortem examinations of the pilot and passenger attributed their deaths to multiple traumatic injuries. The pathologist noted, however, that the pilot had severe coronary atherosclerosis with:

- narrowing of the left anterior descending coronary artery by 75 percent;
- narrowing of the circumflex coronary artery by 90 percent;
- narrowing of the right coronary artery by 60 percent;
- left ventricular hypertrophy; and
- extensive myocardial scarring, left ventricle.

The pathologist reported that due to the extensive injuries sustained by the pilot, he ruled the cause of death to be multiple traumatic injuries. He noted, however, that "the severe arteriosclerotic heart disease suggests the possibility that [the pilot] may have suffered a myocardial ischemia and/or dysrhythmia at the time of the accident."

At the request of the Safety Board, the pathologist sent the pilot's heart and coronary arteries to the Armed Forces Institute of Pathology (AFIP) for further examination.

The AFIP's gross pathology examination concurred with the coroner's findings, adding, however that the pilot's mitral valve was floppy in the posterior leaflet and showed left atrial dilatation. The AFIP pathologist stated, in part:

... portions of [the] coronary artery tree [are] missing (probably removed for paraffin embedding and sectioning) and therefore, the extent of coronary disease may be even more severe than what we report. The patient has a healed myocardial infarct with focal areas of entrapped myocyte within scar dilation which could be secondary to mitral incompetence, but this cannot be definitely judged at autopsy. Both lesions could be a cause of sudden death; however, severe coronary artery atherosclerosis is the most likely cause [emphasis added] [of death] in this patient.

The AFIP Division of Aerospace Pathology physicians reviewed their Department of Cardiovascular Pathology report and concluded that the pilot was at a very high risk for developing a sudden incapacitating arrhythmia due to the previous scarring and occlusive artery disease. They also noted that the floppy mitral valve is, by itself, associated with sudden death.

### 1.14 Fire

There was no postcrash fire.

### **1.15 Survival Aspects**

The impact forces of this accident were not survivable. The coroner's investigators reported that they found the pilot strapped in the right front seat, and the passenger was clear of the wreckage.

The Safety Board examined the passenger's seatbelt and shoulder harness and found that they did not display any evidence of fabric stretching or impact signatures on the metal attach fittings.

The ranch owner told the Safety Board that when the helicopter left his ranch, both occupants were wearing their seatbelts and shoulder harnesses.

### **1.16 Tests and Research**

The Safety Board obtained sworn testimony from both the FAA and private physicians who were involved with the pilot's treatment and recertification process (see appendix A). The Safety Board also retained two cardiovascular physician consultants, Drs. Richard J. Haskell and James P. Lavelle, to review the pilot's medical file and to participate in questioning the physicians. Dr. Lavelle participated in the FAA physician's examination; Dr. Haskell participated in the private physician's examination. Neither of the Safety Board's consultants participated in questioning the FAA's Northwestern Regional Flight Surgeon. The consultants did not confer with each other. Their evaluations of the pilot's medical history, however, were essentially the same.

#### **1.16.1 Safety Board's Consultants Medical Records Review**

**Stress EKG Tests (1984 and 1986).**--The Safety Board's consultants found that the two stress tests given by the AME are uninterpretable due to baseline abnormalities. The tests were abnormal and the AME's protocol was less strenuous than the standard Bruce protocol. The fourth-stage of the AME's test had the exercise equivalence of the third stage of the Bruce protocol. The addition of thallium would be the expected protocol.

There were significant ST segment depressions, between 1 and 2 millimeters (mm). The 1986 stress test ST depressions were less than the 1984 stress test, but the pilot was unable to achieve the same workload during the 1986 stress test; the test was 1 minute 30 seconds shorter.

The pilot's heart rate increased significantly with minimal exercise. The pilot's oxygen consumption was 24 ml/kg/min. According to the consultants, the minimum for untrained males is 30-35 ml/kg/min. This poor performance was probably the result of poor aerobic conditioning.

**Coronary Catheterization (Angiography).**--The consultants generally agreed with the cardiologist who performed the 1984 angiography. Both consultants, however, stated that they observed a 70 to 75 percent narrowing of the left anterior descending artery second septal perforator rather than the reported 50 percent narrowing.

**Consultants' Conclusions.**--The consultants concluded that the pilot's records disclosed that he did not have a single cardiac abnormality, but rather there were multiple cardiac abnormalities--chronic atrial fibrillation, an abnormal submaximal stress electrocardiogram, single vessel coronary artery disease, mild mitral valve prolapse, and a mild diffuse left ventricular dysfunction which is suggestive of an early cardiomyopathy. This condition indicated a greater degree of disease, and therefore, a higher probability of risk for a sudden cardiac event.

The pilot's coronary artery disease had progressed significantly during the 26 months after his angiogram. He was primarily at risk for sudden death due to ventricular fibrillation; he was also at risk for a stroke from an embolus from the heart or another myocardial infarction in other heart areas.

The consultants added that further noninvasive testing, i.e., a thallium or a mugga exercise stress test, would have more readily shown the extent of the pilot's coronary disease.

## **1.17 Additional Information**

### **1.17.1 Sworn Testimony Summary**

**FAA Medical Staff.**--The FAS's staff medical physicians, including the Deputy FAS, testified that the FAS who granted the pilot the special-issuance second-class medical certificate in 1985 did not seek their counsel regarding the pilot's medical certification. The consensus of the staff was that the pilot was not medically eligible for a second-class medical certificate; however, the Deputy FAS, the Aeromedical Division Manager, and the Aeromedical Certification Branch Manager did not advise the FAS of their opinions.

**Designated Airman Medical Examiner-Center for Heart and Health.**--The AME who examined the pilot in 1984 and 1986 stated that the protocol he used was developed by the Center for Heart and Health, a rehabilitation clinic in Inglewood, California. This protocol was used because patients who are in poor physical condition can achieve the maximum treadmill grade level (12 percent) without getting any calf pain problems.

The following are the AME's findings:

- The resting EKG was abnormal such that it showed atrial fibrillation, but there were no ST depressions.
- There were some upsloping 1 to 2 1/2 mm ST depressions on the stress EKG when the pilot achieved the maximum heart rate. He ordered the angiography as a result of the ST depressions.
- He reviewed the pilot's treating physician's report, but did not consult with him.
- The pilot was a personable and robust individual who did not appear to be chronically ill or have any significant disease.

**The Federal Air Surgeon.**--The FAS was appointed by the FAA Administrator on October 1, 1984. At the time of his appointment, there was a considerable backlog of medical review petitions. To eliminate this backlog, the FAS assumed direct control of CAMI with the concurrence of the FAA Administrator. He installed a telex to CAMI for direct communications and required that further tests from airmen petitioning for a medical review be sent to his office. These procedural changes eliminated the backlog.

The FAS instituted an "open door" public policy so that pilots could personally discuss any medical problems with him. The pilot visited the FAS in December 1984, and the FAS did not make any commitments to the pilot, but he promised that he would evaluate the pilot's medical record to determine if the pilot was eligible for a medical certificate.

The FAS reviewed the medical panel's decision to deny the pilot a medical certificate. In his testimony to the Safety Board, the FAS indicated that he thought the panel's write-up was weak and that their assessment that the pilot was a high medical risk was invalid.

The FAS tried to change the panel's method of recommending or not recommending certification in their evaluation by insisting that the medical panel provide him with only a risk evaluation when considering medical certifications; he felt he should decide whether or not the

airman should be medically certified. He stated that the panel resisted his efforts in this matter. He did not forward any subsequent heart special-issuance cases to the medical panel for review.

While the decision to medically recertify the pilot belonged solely to the FAS, he had informally discussed the case with several cardiologists during AME seminars and had asked a consulting cardiologist, who later became the FAA's Northwestern Regional Flight Surgeon, to review the file. The consulting cardiologist provided the FAS with notes that the FAS interpreted to mean that additional medication was all the pilot required.

The FAS acknowledged that both stress tests administered to the pilot were abnormal because of the ST depressions and atrial fibrillation. He noted, however, that in the 1984 stress test, the pilot had achieved 184 beats/min which was greater than the predicted 160 beats/min for his age; the 1986 test showed improvement with respect to the ST depressions, but he did not delineate the improvements. The ST depressions did not show any evidence of ischemia. He was concerned, however, that the 1986 test showed the pilot's functional capacity had decreased (the pilot's inability to continue with the test).

He noted that the pilot's angiogram showed "minimal heart disease" which the FAS concluded required constant monitoring. The FAS relied heavily on the AME's report and the angiography in his evaluation. He thought the AME was a board-certified cardiologist, stating, "... he [the AME] runs a heart institute. His letter[head] says, 'The Center for Heart and Health.'" After his evaluation, the FAS removed the "not valid for PIC" restriction and limited the pilot's medical certificate to 12 calendar months; therefore, it could not automatically revert to a third-class medical certificate and be valid (for private pilot privileges) for another 12 calendar months.

The AME was the consultant referred to in the "consults support" notation in the telex he sent to CAMI concerning the pilot's certification.

**FAA Consulting Cardiologist.**—A consulting cardiologist was retained by the FAA between December 1984 and June 1985 to review the pilots' cardiovascular medical petitions. During that time, he formally reviewed over 50 cardiovascular medical petitions; he also reviewed other petitions that had been reviewed by the panel previously which included the subject pilot's medical records. In these cases, he did not provide a formal opinion nor was he asked to. He had no specific recollection of who asked him to review the subject pilot's file.

The FAA consulting cardiologist concluded that the pilot's medical records review indicated that he was not medically qualified for a second-class medical certificate, particularly for PIC operations. He stated that the pilot's medical records indicated atrial fibrillation and some coronary disease. The stress tests were unreliable as a diagnostic tool because they were abnormal. The cause or origin of the atrial fibrillation was never determined. He stated that in order to determine the cause or origin of the disease, he would have required the pilot to submit to a thallium or mugga stress test.

He could not recall if he gave his informal review notes to the FAS. He did not personally discuss this case with the FAS.

### **1.17.2 Federal Aviation Regulations**

There are three classes of medical certificates available to pilots. A first-class medical certificate is required for airline transport operations that require the PIC to hold an airline transport pilot certificate; the certificate is valid for 6 calendar months. A second-class medical certificate is required for all other commercial operations including on-demand air taxi and some commuter operations conducted under the provisions of 14 CFR 135; the pilot engaged in such operations must hold at least a commercial pilot certificate and the medical certificate is valid for 12 calendar months.



A third-class medical certificate is required for all noncommercial flight activities and is valid for 24 calendar months.

The first- and second-class medical certificates automatically revert to the next lower class medical certificate when the normal expiration date has lapsed; a third-class medical certificate expires at the stated expiration date.

The FAS is authorized, under the provisions of 14 CFR 67.19, to issue a medical certificate to applicants who do not meet the medical standards for the type of certificate they are seeking. The FAS may impose any condition, i.e., (a) establish a limiting period or condition on the certificate; (b) require the applicant to submit to a medical flight test; or (c) require the applicant to provide the results of any additional medical testing necessary to evaluate the applicant's medical condition.

Title 14 CFR Part 67 does not require that any additional medical tests requested by the FAA be performed by a board-certified physician in the specialty of concern. Applicant's for a first-class medical certificate are required to submit to an at-rest EKG on reaching the applicant's 35th birthday or annually after reaching the applicant's 40th birthday. The regulations do not require that any second- or third-class medical certificate applicant submit to an EKG.

Title 14 CFR 67.31 requires applicants to furnish or authorize any medical facility or doctor to release any medical records or information the FAA deems necessary to determine if the applicant meets the medical standards for the certificate they are seeking.

Title 14 CFR 61.53 prohibits any persons from acting as pilot-in-command or as a required pilot flight crewmember with a known medical deficiency that would make them unable to meet the requirements of their current medical certificate.

## 2. ANALYSIS

### 2.1 General

There was no evidence of any failures or malfunctions of the helicopter's airframe or engine. The fracture surfaces of the flight control systems' broken push-pull tubes displayed overload signatures that were caused by impact forces. The oak tree exhibited extensive slash marks and broken limbs indicating that the main rotor blades were operating under power when they struck the tree.

The passenger's body was found away from the wreckage and his seatbelt and shoulder harness disclosed no evidence of any impact signatures. The ranch owner stated that the pilot and passenger were wearing their seatbelts and shoulder harnesses when they departed. The Safety Board concludes that during the 15-minute flight, the passenger removed his seat restraints before the accident which reinforces the probability that the pilot became incapacitated and that either the passenger attempted to assist him before the crash or that the pilot attempted to extricate himself from the aircraft before impact.

The helicopter was not equipped with a flight data recorder, therefore, the exact power being developed at the time of the accident could not be determined. The engine disassembly examination, however, disclosed that the compressor, turbine, and impeller housing exhibited extensive damage. The extensive rotational scoring and ruptures of the housing adjacent to the rotating groups indicate high rotational speed. The aluminum metallization deposits on the first-stage nozzle vanes, the aluminum shavings on the compressor diffuser vane, and the heat discoloration adjacent to the punctured exhaust transfer tubes also indicate that there was combustion at impact.

In view of the apparent absence of any airworthiness problems in the aircraft that may have caused the aircraft's abrupt change in flightpath just before the crash, the Safety Board also examined the possibility of pilot incapacitation. This area of investigation included the pilot's medical background and the FAA's special-issue certification practices.

### 2.2 Pilot Operational/Medical Factors

The investigation showed that the pilot disregarded FARs on several occasions. The pilot had paid civil penalties as a compromise settlement for two incidents that allegedly violated the FARs. One of the alleged violations concerned low-flying activities, similar to the manner in which he was flying immediately before the accident. In addition, the Safety Board concludes that the pilot was flying the helicopter during another low-flying incident on the day before the accident which further demonstrated his predilection for low flying. The Safety Board believes the pilot was flying in a similar manner immediately before the accident; however, had he been flying at a higher altitude, the outcome would not have changed.

Investigators determined that although he was employed as a pilot from January 1982 through 1985, he did not possess a valid medical certificate. Based on his medical treatment and consultation, the Safety Board believes the pilot was aware that his medical condition would prevent his obtaining a second-class medical certificate. This is demonstrated in his letter to the FAS in which the pilot thanked him for "legally getting him back into the air" shortly after receiving his limited (not valid for PIC) second-class medical certificate.

Ironically, the pilot probably received his current medical certificate that allowed him to resume commercial pilot-in-command activities while he was in the hospital recovering from a myocardial infarction. The FAA's Aeromedical Certification branch manager admonished the pilot to cease his

flying activities if his medical condition changed adversely; the pilot did not comply with the admonition, and he continued his flying activities.

In view of the pilot's medical history, the Safety Board concludes that the pilot was not medically qualified to fly. The Safety Board believes that the pilot failed to abide by FARs when he continued to fly after he had suffered a myocardial infarction.

The 1984 medical exam indicated that the pilot had multiple cardiac abnormalities including chronic atrial fibrillation, an abnormal submaximal stress electrocardiogram, single vessel coronary artery disease, mild mitral valve prolapse, and a mild diffuse left ventricular dysfunction which is suggestive of an early cardiomyopathy. Any one of the abnormalities alone may have been disqualifying, but combined, these conditions clearly rendered him ineligible for any medical certificate.

### **2.3 FAA Certification**

While the Safety Board is aware that it is the responsibility of the FAS to recertify airmen, it believes the FAA medical panel members should have provided the FAS not only their medical findings but also a detailed risk evaluation of the pilot. In this instance, the medical panel merely related its medical findings and recommended that the pilot not be certified. The FAS, at the time the panel made the recommendation, agreed and advised the pilot accordingly. There is no evidence to indicate that the newly appointed FAS consulted with any of the medical panel members when he was evaluating the pilot's request to be recertified. The Safety Board believes that the FAS should have consulted with his medical staff when the area of concern is not related to his medical discipline regarding the recertification of the pilot. In addition, the medical staff should have voiced their opposition and provided the FAS their reasons for recommending that the pilot not be certified.

The FAS asked the FAA's consulting cardiologist to review the pilot's medical file, but he did not ask for nor was he provided with a formal risk evaluation report. The cardiologist's notes indicated that he was opposed to issuing any pilot-in-command second-class certificate without additional thallium or mugga stress exercise tests. Testimony given by the FAS and the consulting cardiologist disclosed that they never formally discussed the pilot's special-issuance medical certificate application.

When the FAS initially granted the pilot a special-issue second-class medical certificate, he acceded to the cardiologist's recommendations on his notes and did not certify the pilot for a pilot-in-command certificate. It is apparent that the FAS disregarded the cardiologist's questions on his notes regarding the possibility of early cardiomyopathy and the need for additional thallium or mugga stress tests.

The medical records do not show that the FAS requested any additional tests before he concluded that the pilot was qualified for a special-issue second-class medical certificate. Also, the records do not indicate that the FAS, the AME, or the panel requested the pilot's treating physician reports, even though the pilot noted on his 1984 medical application that he had been treated for atrial fibrillation. The Safety Board believes that a review of the pilot's treating physician's records would have shown a consistent decline of the pilot's cardiac health and would have alerted the FAS to the physically deteriorating condition of the pilot. Had the FAS reviewed the pilot's medical records thoroughly and become aware of his condition, the Safety Board believes he would have had to deny the pilot his medical certificate. The FAA should institute procedures and associated recordkeeping to show that the FAS or a medical consultant(s), at least one of whom is recognized and certified in the medical discipline under consideration, review all treating physicians diagnosis before issuing a medical certificate under the provisions of 14 CFR 67.19.

The 1986 stress test results showed that the pilot's functional capacity had declined and suggested that the extent of the pilot's heart disease probably had increased. The Safety Board believes that the FAS should have requested the thallium or mugga stress test before he decided to recertify the pilot. The Safety Board also believes that the FAS erred when he relied strictly on the available stress test results since they were not valid indicators of the extent of the pilot's heart disease.

In the August 27, 1985, renewal letter, the Aeromedical Certification branch manager advised the pilot to provide the FAA with a cardiac evaluation conducted by an "internist or cardiologist." The FAS believed that the AME was a board-certified cardiologist. This belief was reinforced by the AME'S letterhead which read, "The Center for Heart and Health." The Safety Board is concerned that the FAA does not have any procedures to determine that cardiac evaluations submitted by pilots have been performed by board-certified cardiologists.

## **2.4 Medical Evaluation Tests**

The Safety Board believes that the FAA should require a standard protocol be used for any required stress EKG. In this instance, the FAS noted that the pilot was able to attain the fourth stage of a nonstandard stress test, but the test administered to the pilot, however, was equivalent to the third stage of the standard Bruce protocol. Had the pilot been given a standard Bruce protocol, he probably would not have been able to reach the fourth stage. These data would have been invaluable to the FAS during his evaluation of the pilot's medical condition.

### 3. CONCLUSIONS

#### 3.1 Findings

1. The helicopter was certified and maintained in accordance with current applicable FARs and established maintenance procedures.
2. The helicopter did not sustain any malfunctions or failures before the accident.
3. The pilot had previously disregarded the FARs on at least two occasions.
4. At the time of the accident, the pilot was flying too low over persons and property; however, had he been flying at a higher altitude, the outcome would probably have been the same.
5. The AME did not use the standard Bruce protocol when he performed the pilot's exercise stress tests.
6. The exercise stress test results were abnormal and uninterpretable as a diagnostic tool.
7. The available medical data indicated the pilot had multiple cardiac abnormalities at the time of the accident including chronic atrial fibrillation, an abnormal submaximal stress electrocardiogram, multiple vessel coronary artery disease, mild mitral valve prolapse, and a mild diffuse left ventricular dysfunction which is suggestive of an early cardiomyopathy.
8. The FAS rejected the FAA medical panel members' recommendation that the pilot's medical certificate application be denied. The FAS did not seek the advice of his medical staff, nor did the medical staff offer a risk evaluation of the pilot.
9. The FAS did not request a formal report from the FAA's consulting cardiologist and did not request the thallium or muga tests suggested by the FAA's consulting cardiologist.
10. The AME was not a board-certified cardiologist.
11. A board-certified cardiologist or internist was not involved in the pilot's 1986 cardiac evaluation.
12. The FAS relied solely on the AME's medical evaluation and recommendation to certify the pilot.

#### 3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the pilot's incapacitation resulting from a myocardial event. Contributing to the cause of the accident was the pilot's failure to comply with the provisions of both his medical and pilot certificates and the inadequate procedures used by the Federal Air Surgeon to medically recertify the pilot.

#### 4. RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board made the following recommendations to the Federal Aviation Administration:

Require that persons applying for special-issuance medical certificates under the provisions of Title 14 Code of Federal Regulations 67.19 provide evidence that any requested cardiovascular evaluations were performed by a physician certified by the American Board of Cardiology and that a recognized standard protocol was used in any related stress electrocardiogram examination. (Class II, Priority Action) (A-88-59)

Institute procedures and associated recordkeeping to show that the Federal Air Surgeon or a medical consultant(s), at least one of whom is recognized and certified in the medical discipline under consideration, review all treating physician(s) diagnosis before issuing a medical certificate under the provisions of Title 14 Code of Federal Regulations 67.19. (Class II, Priority Action) (A-88-60)

#### BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT  
Chairman

/s/ JAMES L. KOLSTAD  
Vice Chairman

/s/ JOHN K. LAUBER  
Member

/s/ JOSEPH T. NALL  
Member

May 2, 1988

**APPENDIXES****APPENDIX A****INVESTIGATION AND HEARING****Investigation**

The Safety Board was notified of the accident on August 3, 1986, at 1300 Pacific standard time. A field investigator from the Safety Board's Los Angeles Field Office was immediately dispatched to the scene. There were no investigative groups formed. The Safety Board retained two cardiologists to assist the investigator-in-charge in evaluating the pilot's medical history.

Parties to the investigation included the FAA and Bell Textron Helicopter Company.

**Hearing**

A public hearing was not conducted. Three 1-day deposition proceedings were conducted at the Safety Board's Los Angeles field office, Los Angeles, California, on August 28, 1986, at the Safety Board's headquarters, Washington, D.C. on February 12, 1987, and at the Safety Board's Seattle field office on March 17, 1987.

## **APPENDIX B**

### **PERSONNEL INFORMATION**

#### **Pilot-in-Command**

Joseph Anthony O'Brien, 49, held an airline transport pilot certificate No. 1812255 with an airplane single-engine land rating. The certificate was endorsed for commercial privileges in an airplane multiengine land and rotorcraft- helicopter.

The pilot also held an advance ground instructor certificate No. 51322935; the certificate was issued on February 19, 1974. The pilot last renewed his flight instructor certificate, with airplane single- and multiengine and instrument-airplane rating on May 30, 1980. The certificate was valid until May 31, 1982.

At the time of the accident, the pilot had been on duty for about 2 hours. He had flown about 35 minutes up to the time of the accident.

#### **Frank H. Austin, M.D. (Federal Air Surgeon)**

Dr. Frank H. Austin, currently associated with the National Aeronautics and Space Administration, is a graduate of Southwestern Medical School at the University of Texas.

Dr. Austin specializes in occupational and aerospace medicine. He is a member of the American Board of Preventive Medicine.

Dr. Austin served as the FAS from October 1984 until February 2, 1987. Dr. Austin was formerly a Senior Flight Surgeon for the U.S. Navy.

#### **Designated Airman Medical Examiner (Center for Heart and Health)**

William F. Brath, M.D., M.P.H., is the director of the Center for Heart and Health. Before joining the Center, Dr. Brath served for 3 years as Director, Area Medical Services for Trans World Airlines, Inc., (TWA) and 12 years in the U.S. Air Force as Chairman, Department of Aerospace Medicine and Environmental Health Services; he is also a certificated pilot.

Dr. Brath graduated from the University of Chicago Medical School and holds a Master's Degree in Public Health from the University of California, Berkeley, California, School of Public Health. He holds the following medical affiliations: Certified, American Board of Preventive Medicine; Fellow, American College of Preventive Medicine; Associate Fellow, Aerospace Medical Directors Association; American Medical Association; California Medical Association; Los Angeles County Medical Association; and Westchester Medical Society.

In his capacity as Director, Area Medical Services at TWA, Dr. Brath administered comprehensive medical selection and continuing evaluation programs for pilots, flight attendants, and management personnel.

As a FAA Designated Senior Aeromedical Examiner, Dr. Brath can issue first-, second-, and third-class FAA medical certificates to qualified airmen. Dr. Brath has had extensive experience in sponsoring airline pilots in petitions of exemptions from the FARs with a history of coronary artery disease and alcoholism.



**APPENDIX B**

In addition to his other duties at the Center, Dr. Brath serves as Director, Department of Aerospace Medicine, Daniel Freeman Hospital Medical Center, Inglewood, California.

**Dr. James P. Lavelle, Jr., M.D. (Consultant to the Safety Board)**

Dr. Lavelle is an instructor, Department of Medicine, Division of Cardiology, Georgetown University Hospital, Washington, D.C. Dr. Lavelle is board-certified in internal medicine and his board certification in cardiovascular diseases is pending.

**Dr. Richard J. Haskell, M.D. (Consultant to the Safety Board)**

Dr. Haskell is board-certified in internal medicine and cardiovascular diseases and is an Adjunct Assistant Professor of Medicine, University of California, Los Angeles, School of Medicine.

**Malcolm R. Parker, M.D. (Former FAA Northwest Region Flight Surgeon)**

Dr. Parker was the consultant to the FAS from January 1986 to April 1986. Dr. Parker is board-certified in internal medicine and cardiology.

**Stephen J. Schnugg, M.D.**

Dr. Schnugg, who was Mr. O'Brien's treating physician graduated from the University of California, Los Angeles, School of Medicine, and is board-certified in internal medicine with a subspecialty in cardiology. Dr. Schnugg specializes in cardiology.

**Attendee's at the June 7 - 8, 1984 Medical Consultant's Meeting**

The medical panel that evaluated Mr. O'Brien's application for a special-issuance medical certificate consisted of seven physicians, three of whom were board-certified cardiologists. The following are the board-certified cardiologists: Earl F. Beard, M.D., Houston, Texas; Myrvin H. Ellestad, M.D., Long Beach, California; and Milton J. Sands, Jr., M.D.

## **APPENDIX C**

### **GLOSSARY OF MEDICAL TERMS**

#### **Acute Lateral Myocardial Infarction**

Defining the location of the muscle damage as viewed from the front, facing the patient.

#### **Anteroseptal Wall**

The area in the front part of the muscular wall between the two sides of the heart. In the context of this report, it is addressing the ventricles or "high pressure" part of the heart.

#### **Arrhythmia**

Any variation from the normal rhythm of the heart beat.

#### **Atrial Fibrillation**

Abnormal contraction of the auricular (upper part of the heart/upper chamber).

#### **AV Groove**

A groove that is formed around the heart at the junction of the atria and ventricles.

#### **Bruce Protocol**

The standard exercise protocol used by most cardiologists in performing a stress electrocardiogram.

#### **Cardiomyopathy**

A disease process in the heart not related to the blood supply of the heart. The cause is usually associated with a virus or alcohol.

#### **Coronary Angiography**

An injection of the heart arteries to aid seeing the inside of the coronary vessels by x ray.

#### **Digoxin Medication**

A medication that alters the contractility and conduction of the heart, trade name Lanoxin (digitalis type).

#### **Echocardiogram**

A visualization of a section of the soft tissue of the heart using ultrasound.

#### **Electrical Cardioversion**

A method of using electrical current through the heart to try to reestablish a normal heart rhythm.

**APPENDIX C****Hypertrophy (Ventricular)**

The enlargement or overgrowth of the ventricle.

**Hypokinesis**

Less than normal movement of the heart.

**Ischemia**

A deficiency of the blood supply to the heart muscle due to obstruction or constriction of the coronary arteries.

**Mitral Valve Prolapse**

The valve is located between the left atrium and left ventricle of the heart. Prolapse refers to the abnormal backward movement of the mitral valve during contraction of the left ventricle. This condition occurs in about 10 percent of the population and is of no prognostic significance if it is not associated with insufficiency (leaking) or arrhythmias. If combined with arrhythmias it may be associated with sudden death.

**Muga Exercise Stress Test**

An angiogram type study using nuclear isotopes.

**Septum**

A dividing wall or partition; the portion of tissue that divides the heart into right and left.

**ST Depression**

A portion of the EKG complex as recorded between the electrical contraction and the repolarization which is normally flat. A standard normal depression is less than 1mm on exercise at 85 percent or more of the predicted maximum heart rate.

**Stenosis**

A narrowing or diminution of any heart passage or cavity.

**Thallium**

A nuclear test that helps determine the blood flow to the heart muscle.

**Ventricle**

One of the lower chambers of the heart.

**Ventricular Fibrillation**

Abnormal rhythm of the large chamber of the heart which is frequently fatal.

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