**NATIONAL TRANSPORTATION SAFETY BOARD**
**OFFICE OF AVIATION SAFETY**
**WASHINGTON, D.C. 20594**

October 1, 2002

# ADDENDUM NUMBER 1 TO THE SYSTEMS GROUP CHAIRMAN'S FACTUAL REPORT OF INVESTIGATION CONCERNING THE ARTIFICIAL FEEL AND TRIM SYSTEM

DCA02MA001

## A. ACCIDENT

| | |
|---|---|
| Operator: | American Airlines |
| Aircraft: | A300-600R |
| Location: | Belle Harbor, New York |
| Date: | November 12, 2001 |
| Time: | 09:16 EDT |

## B. SYSTEMS GROUP

| | |
|---|---|
| Chairman | Steven Magladry<br>National Transportation Safety Board<br>Washington, DC |
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| Member | Peter Ehlers<br>Airbus Deutschland<br>Hamburg, Germany |
| Member | Willi Burfeindt<br>Airbus Deutschland<br>Hamburg, Germany |

## C. SUMMARY

On November 12, 2001, about 0916 Eastern Standard Time, American Airlines flight 587, an Airbus A300-600, was destroyed when it crashed into a residential area of Belle Harbor, New York, shortly after takeoff from the John F. Kennedy International Airport (JFK), Jamaica, New York. Two pilots, 7 flight attendants, 251 passengers, and 5 persons on the ground were fatally injured. Visual meteorological conditions prevailed and an instrument flight rules flight plan had been filed for the flight destined for Santo Domingo, Dominican Republic. The scheduled passenger flight was conducted under 14 CFR Part 121.

The systems group removed a number of components from the accident site for further examination. The Artificial Feel and Trim Unit (AFTU), a part of the rudder differential unit installed in the fuselage below the vertical stabilizer, was one of those components. The AFTU is a significant element of two functions; artificial feel forces to the rudder pedals and rudder trim.

Artificial rudder feel is implemented by connecting the rudder pedals through linkages that must compress springs in the AFTU in order to move the output to the rudder. Rudder trim is implemented by adjusting the length of the AFTU through an internal jackscrew.

Examination and tests of the AFTU were performed at the production facility at Airbus Deutschland, GMBH between April 11 – 12, 2001. It was found that some internal components were damaged by the post accident fire. The spring feel force could not be tested because melted components impeded the spring from compressing. The rudder trim jackscrew and nut portion were found in relatively good condition.

This addendum provides a description of the A300-600 artificial feel and trim system and the details of the examination of the accident airplane AFTU.

## D. DETAILS OF THE INVESTIGATION

1.0 Description of the Artificial Feel and Trim System

An artificial feel and trim unit is installed adjacent to the rear cable quadrant (Figure 1). It consists of a trim screwjack and a fail-safe constant resisting load spring rod, held in neutral position by the trim screwjack (Figure 2). The spring rod function is:

1.1 To maintain the downstream linkage and the input lever of the servo controls at neutral in the event of disconnection of the control linkage upstream of the artificial feel and trim unit.

1.2 To provide artificial feel loads proportional to rudder deflection
1.3 To provide accurate centering of the surface at neutral in the absence of a control input
1.4 To maintain the upstream controls at neutral, when inputs are provided to the servo controls by the yaw damper actuator.

The AFTU is designed to produce pedal displacement versus pedal force characteristics shown in Figure 3. The feel forces do not change as a function of airspeed.

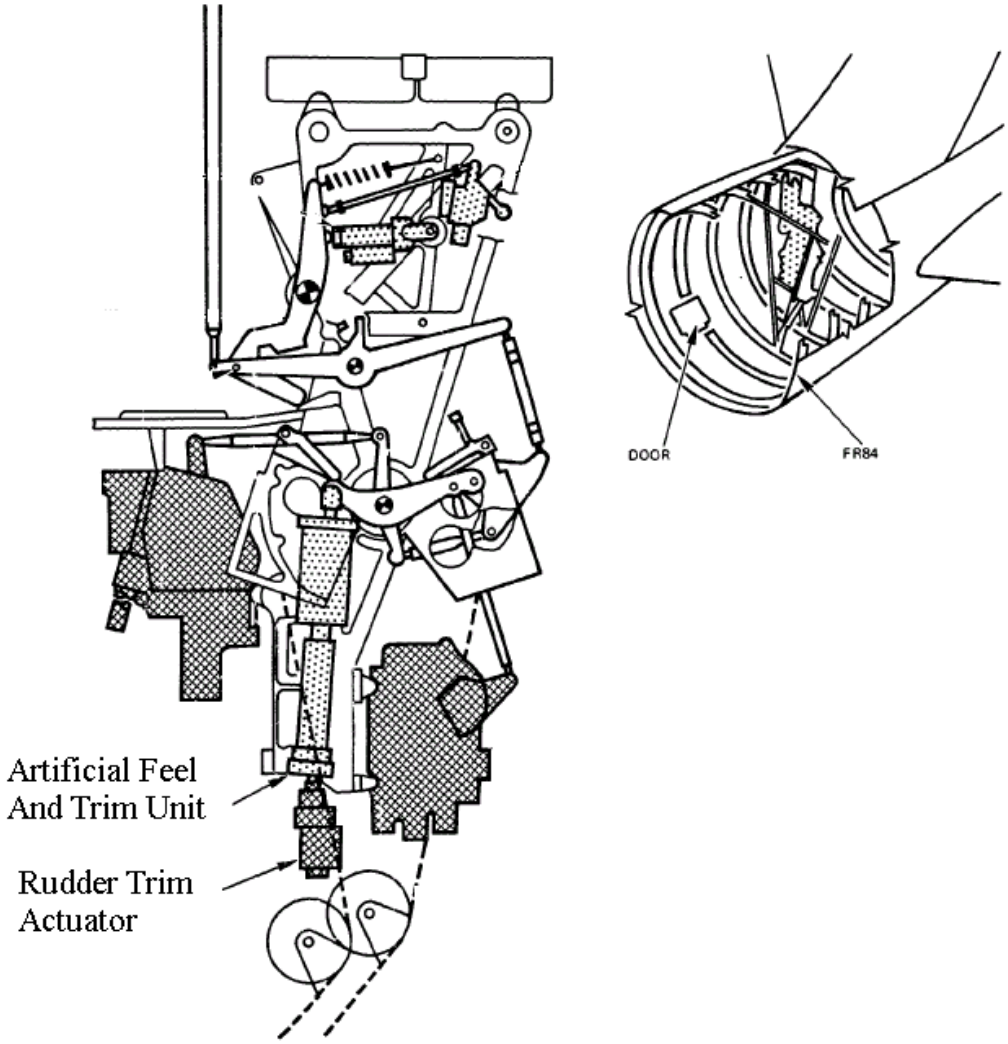


Figure 1. Artificial Feel and Trim Installation.

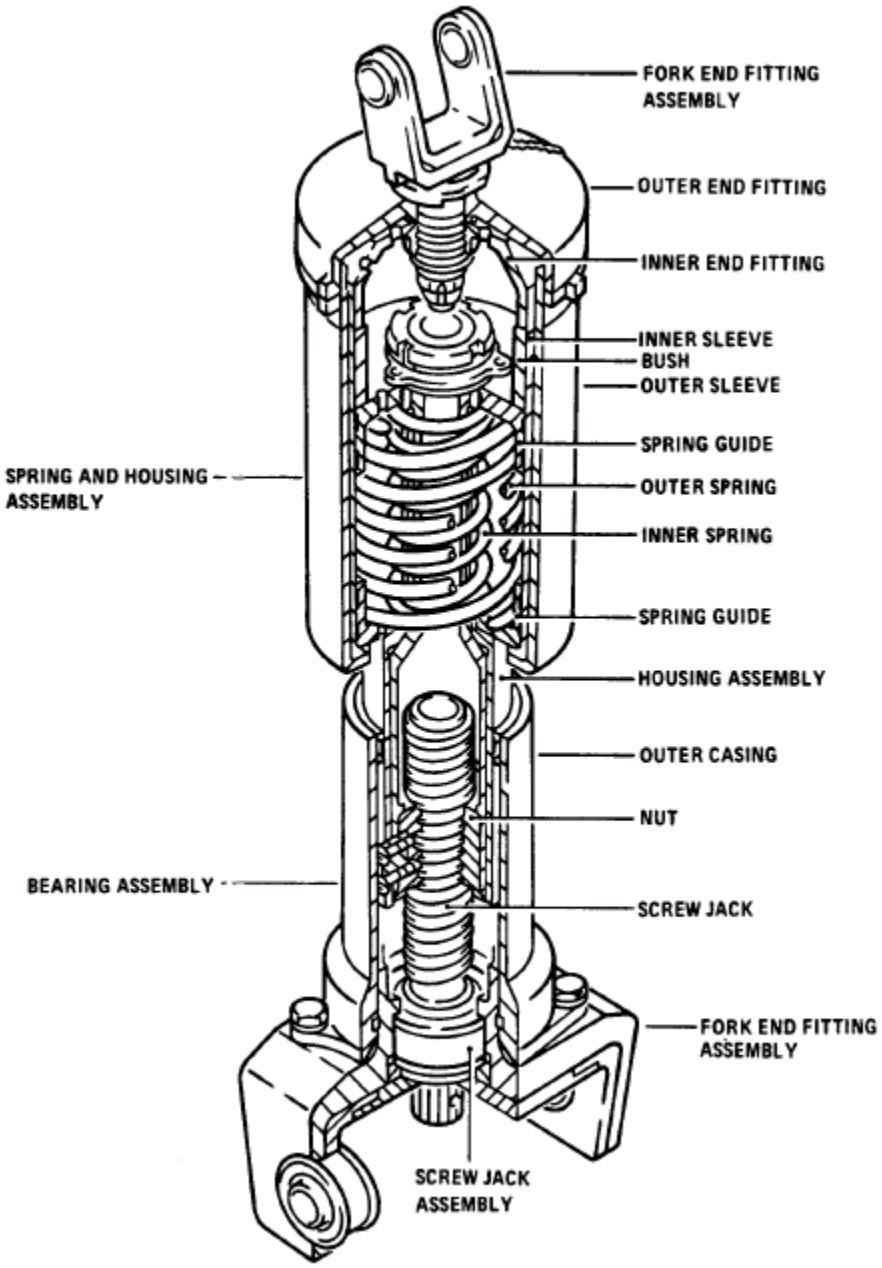


Figure 2. Artificial Feel and Trim Unit.

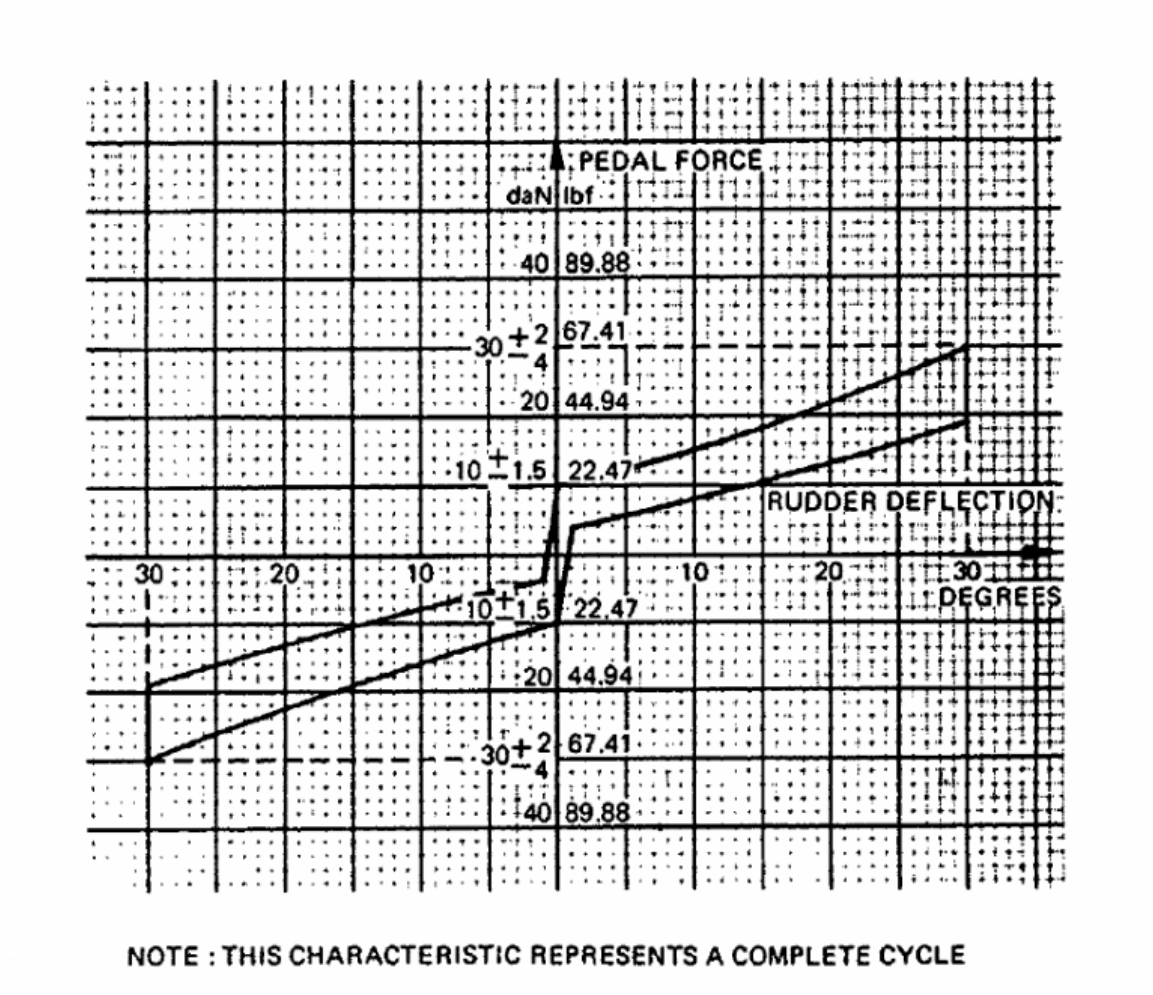


Figure 3. Rudder Feel Forces

## 2.0 Condition of Accident Airplane AFTU

The part was found at the accident site, near other melted components of the rudder differential unit. The AFTU had separated from the lower attachment structure, with small pieces of the structure still attached to the lower fittings. The unit was also found separated from the rudder trim motor, with part of the universal joint still attached to the screwjack splines. The upper attachment point was still attached to the main bellcrank of the control linkage. All externally observable parts of the AFTU were intact (Figure 4). The part had black deposits over the surface. The paint was not present, and there was bare metal in places. A slight side to side freeplay was observed between the spring's housing and the screwjack housing. A slight axial freeplay was also observed. Two digital radiographs of the AFTU are shown in Figure 5. They did not reveal any major damage to the internal parts, except for possibly some deformation of inner sleeve, which retains the springs.

Figure 4. Accident airplane AFTU.

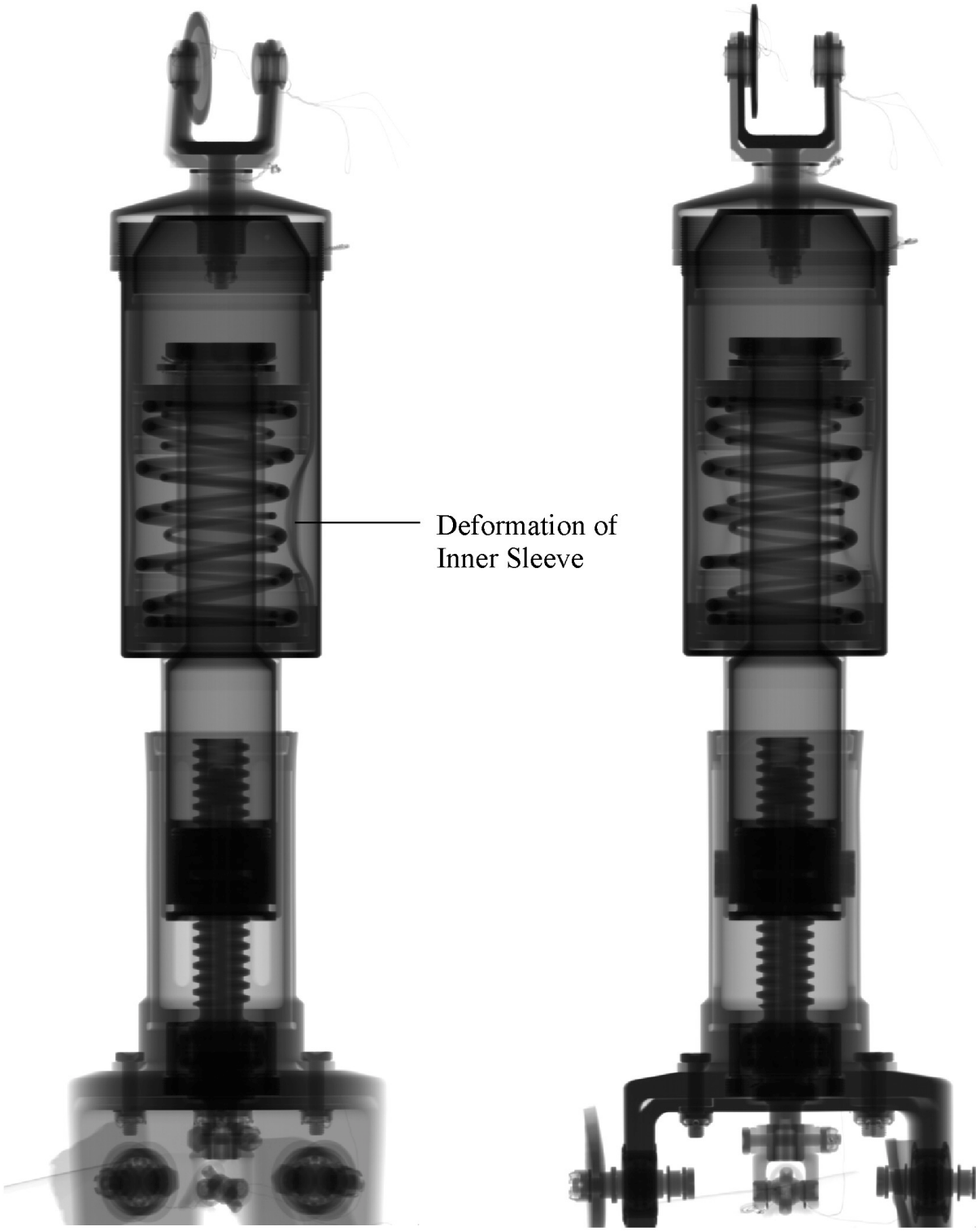


Figure 5. Digital Radiographs of Accident Airplane AFTU.

## 3.0 Dimensional Checks and Observations

The length of the part, from the center of the attachment fittings, was measured by Airbus technicians to be 420.471 mm. The neutral position for the actuator, per Airbus drawing A27271325, is 420.9 mm and the total theoretical travel is +/- 30 mm.

It was noted that normally the AFTU can be partially depressed by a hand force of approximately 56 DaN. Moderate force was applied by hand and the assembly would not compress. It was noted that the unit likely experienced high temperatures during the post accident fire. It was speculated that this may have embrittled the internal springs or damaged internal parts and as such a normal ATP test should not be performed. The group agreed to this, and proceeded with a disassembly of the unit per CMM 27-31-11, Revision 16, dated Sept 1/97.

## 4.0 Disassembly of the AFTU

Only exceptions to a standard disassembly are noted. Illustrations of the item numbers are provided in Figures 6 and 7, followed by pictures of the items in Figures 8 and 9.

The item 100 inner end fitting could not be separated from the item 210 inner sleeve. A band saw was used to separate the item 100 part from item 210. This did not damage any other parts.

The inner sleeve, made of an aluminum alloy, was collapsed in on the item 190 outer spring. The sleeve was formed to the contour of the spring in some places (Figure 10). This restricted the compression of the outer spring and impeded any motion of the item 160 lower spring guide. The upper spring guide slip rings, made of Teflon, were partially melted. The inner spring was free to be removed from the assembly, but to remove the outer spring it was necessary to cut the inner sleeve.

The uncompressed inner spring was measured to be 90.15 mm. The uncompressed outer spring was measured to be 83.2 mm

The spring rate of each spring was determined by a calibrated load cell. The inner spring was compressed 50 mm under a load of 67 N - spring rate => 1.34 N/mm. The spring rate per the drawing is 1.15 N/mm. The outer spring was compressed 10 mm under a load of 85.4 N – spring rate => 8.54 N/mm. The specification per drawing is 8.22 N/mm.

The item 56, silicone seal ring was brittle and segmented.

Considerable force was required to rotate and remove the item 10 outer casing from the item 100 fork end fitting. After removal the outer casing appeared to be slightly

ovalized. Two cracks were observed on the fork end fitting. The cracks are illustrated in Figure 11. The cracks appear to have deposits in them.

The item 70 screws could not be turned, so they were drilled out. The item 190, bearing did not rotate freely and the inner diameter was seized to the item 88 screwjack. This prohibited the removal of item 82 and the screwjack assembly from the item 100 fork end fitting. The screwjack was therefore removed from the item 86 nut by rotation, allowing the removal of item 82 from item 100.

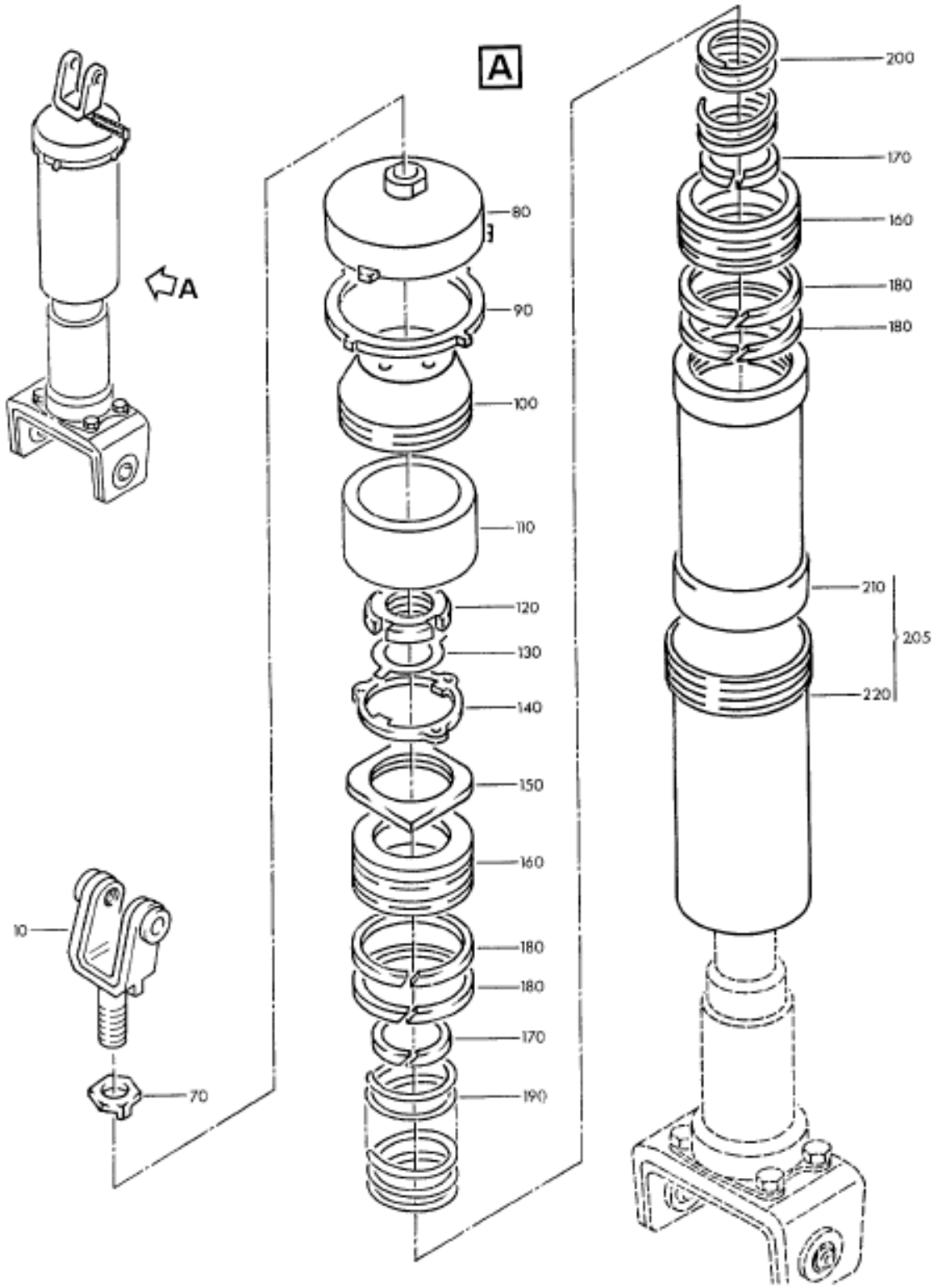


Figure 6. AFTU Spring Rod Assembly.

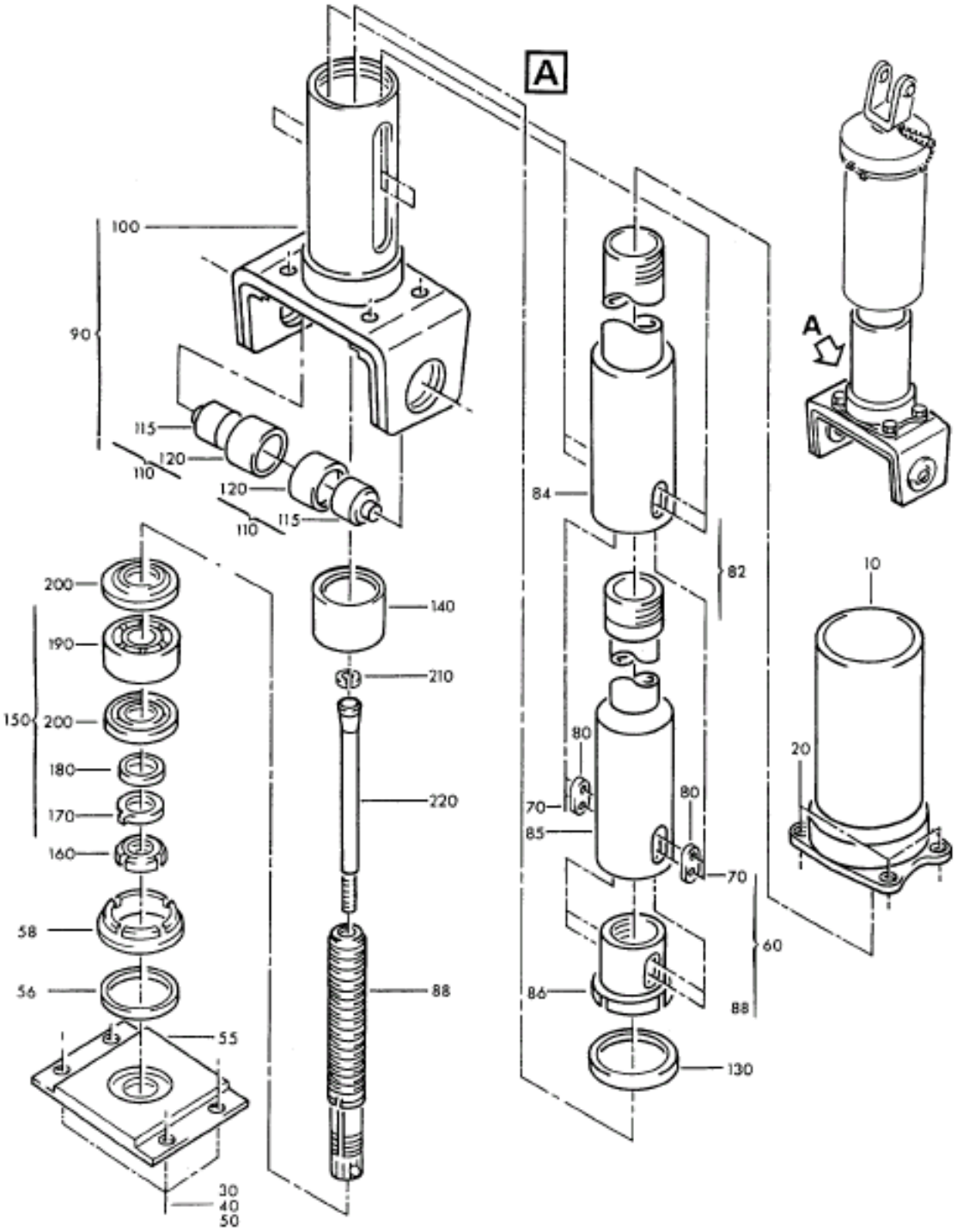


Figure 7. AFTU Screwjack Assembly.

Figure 8. AFTU Spring Rod Assembly.

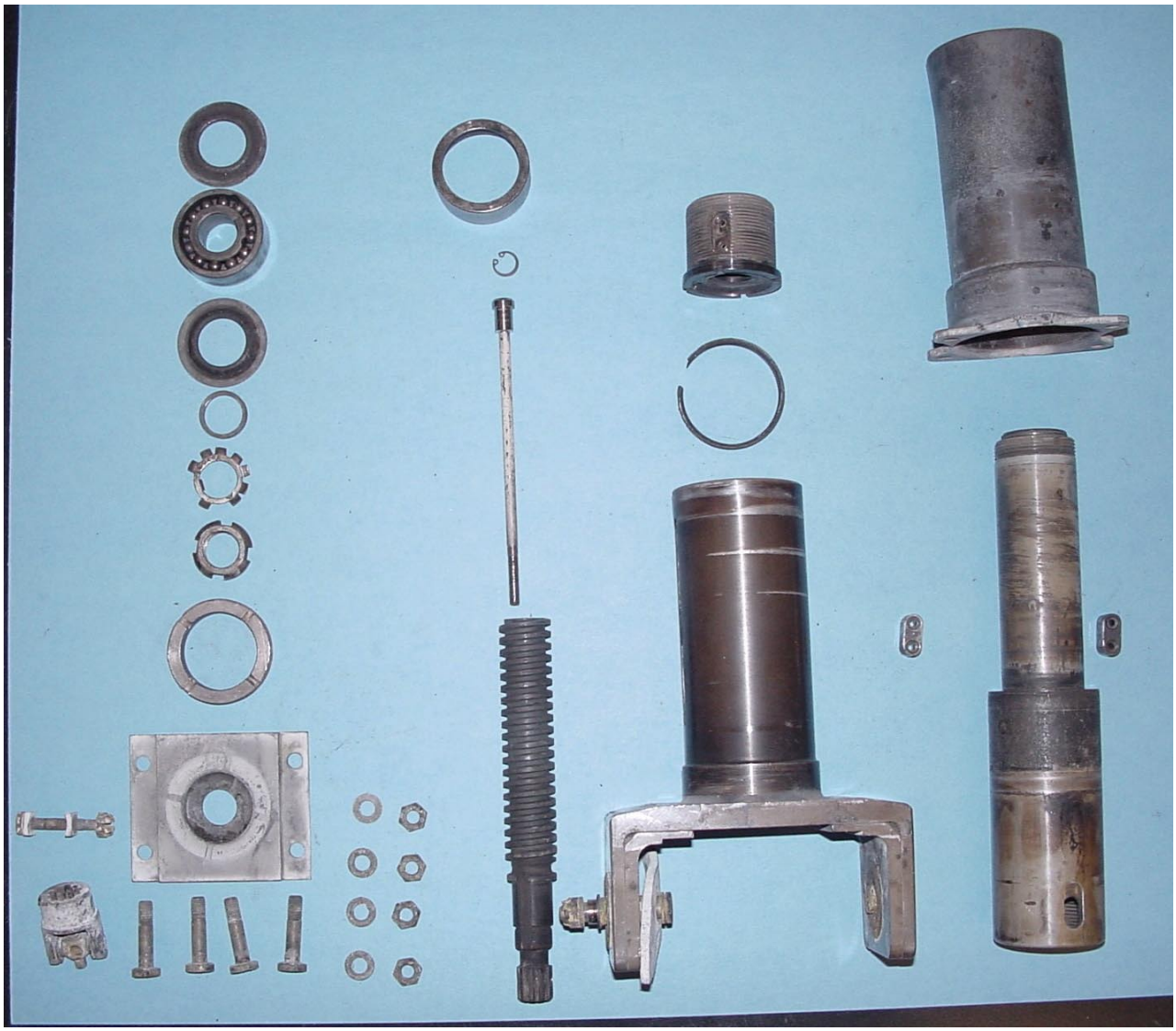

Figure 9. AFTU Screwjack Assembly

Figure 10.  Deformation of item 210 inner sleeve

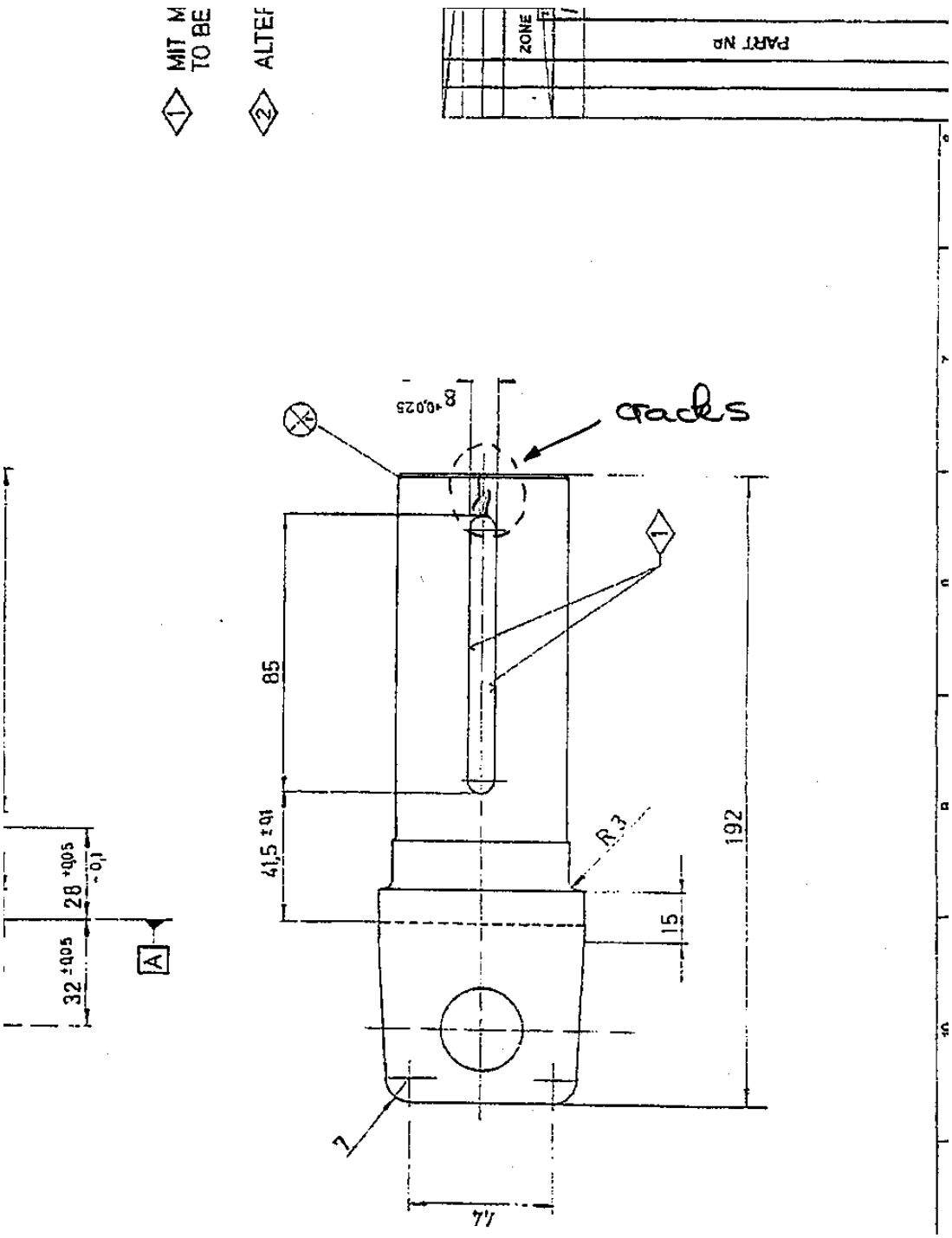


Figure 11. Cracks in Item 100 Fork End Fitting.

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