REVIEW OF AIDS DEVELOPMENT

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SUMMARY

Since the introduction of the wide-body aircraft KLM, SAS and Swissair have been able to collect a mass of experience, meager as will as excellent and in total profitable. All three are very determined to continue with AIDS on A300/310 Airbus (Swissair also on the DC-9-80).
The A300/310 AIDS as selected by KSS (KLM, SAS and Swissair) and Lufthansa has been developed into a very powerful Engine Monitoring System (EMS) and engineering tool capable to enhance aircraft regularity, reliability and economic operation.

INTRODUCTION

KLM, SAS and Swissair started with AIDS at the introduction of the wide-body aircraft in 1970. The AIDS hardware specification for the Boeing 747 and McDonnel Douglas DC-10 aircraft was based on the experience obtained from:

- A digital recording experiment by KLM on a Douglas DC-8 in 1963 and 1964 (3) and DC-9 trials with prototype equipment in 1969.
- The development of the ARINC 573 specification for a Flight Data Acquisition Unit (FDAU) to satisfy the new FAA requirements.

The initial objectives of KSSU with respect to the AIDS were primarily directed to the monitoring of parameters related to:

- the safety of the flight
- the performance of the aircraft
- the performance of the flight guidance system
- the performance and condition of the engines.

The AIDS-EMS function was and still is considered supplemental to the existing monitoring tools.
For AIDS-EMS practically the same parameters were selected as already provided for display on the cockpit instrument panels with a few exceptions. Table 1 provides a list of EMS parameters monitored on KSSU aircraft. The total number of parameters monitored on KSSU 747 and DC-10 aircraft amounts to 380 and 280 respectively of which more than 50% are discretes (on/off signals).

In order to accomodate all these parameters and enable sampling at reasonable rates the system was configured around 3 Data Acquisition Units and a Data Management Unit (DMU) with limited data acquisition capability. Figure 1 depicts the system block diagram.

AIDS OPERATION

In KSS the AIDS is primarily applied as an engineering tool with a strong emphasis on analysis of recorded information. A printer was added to the airborne system because it was recognized rather early that hard copies of exceedance reporting could provide a very effective aid in trouble reporting. The application of on-board processing for limit exceedance monitoring and recording control allowed to add a printer which could provide hard copy reports on request by the crew or automatically.

The tape-cassette is removed every landing made at the home-base and is subsequently transcribed to IBM compatible tape and processed. The routine programs applied comprise o.a.: flights logging, AIDS status reporting, EMS programs, autoland verification, etc.
For a good understanding of the function of AIDS in an EMS, it is essential to give some details on the functions of two specific software programs: the AIDS flight logs and the plot/list program. The first program provides a listing of all recorded flights per aircraft registration and the second program allows users to request a time history of a set of 8 analog plus 8 discrete type parameters either in table format or plotted. The user can call the AIDS flight log, select the airplane, the flightleg and the parameterset of interest and request a listing either for a specified flight mode or a GMT time span using the VDU terminals of KLM's data handling system. The very successful use of this program proved that AIDS is an invaluable engineering tool and fully met the set objectives.

CURRENT AIDS EMS APPLICATIONS

ON BOARD

For short-term trend analysis KLM relies on a trendchart that is updated by the flight engineer on every flight that lasts more than 4 flight hours. The flight engineer then selects a stabilized flight condition to request and engine data print (table 2). The flight engineer uses this print to calculate the trend delta's with the aid of an engine performance calculator provided by the engine manufacturer and enters the delta values in his trend chart. Engine bleed and engine indicating problems, serious compressor/turbine problems and EGT-margin losses can be detected by the flight engineer using these short term trends. In addition these trends are checked by powerplant engineers on a regular basis and in case of crew complaints.

The engine data prints are also automatically presented during take-off and in case of limit exceedance e.g. the print of table 2 shows an automatically reported impending hotstart on engine nr. 1.

The take-off prints are used to monitor the hot-day EGT margin, thrust settings etc. Crew complaints are supported by prints selected by the flight engineer and/or limit exceedance prints. In case of critical engine problems the flight engineer will contact the main-base via a single-sideband company channel for expert advise. With aid of the print he is able to provide exact information on the characteristics of the trouble or exceedance, the exact durations and the peak values of exceedances.

Strict adherence to the manufacturers engine operating limits could increase the number of engine removals because of the capability of EMS to very accurately report exceedances of operating limits that are based on experience, which include the human factor. It is obvious that these limits need to be adapted when an advanced EMS is used to prevent increased removals or inspection rates. KLM was able to obtain the approval to extend the limit on the allowable EGT exceedance time-limit on a particular engine when using the AIDS printer. This printer function has proven an invaluable tool for short-term engine monitoring, incident reporting and trouble-shooting to the extent that powerplant engineers consider this feature alone was worth the investment in AIDS.

GROUND-BASED LONG TERM ANALYSIS

For long term trend analysis the AIDS provides weekly trend reports on KLM's JT9D and CF6 engines. These trend reports consist of 3 parts viz. an engine start trend (fig. 2a), an engine take-off trend (fig. 2b) and an engine cruise trend (fig. 2c). The trends shown apply to the Pratt&Whitney JT9D engine as installed in KSS 747 airplanes.

Engine start trend

Of the engine start trend one important feature should be adressed. After careful analysis using the AIDS plot/list program KLM engineering decided to trend the initial fuel flow (IFF) at the moment of "fuel-on". This analysis showed that by monitoring this value it was possible to relate a positive or negative deviation from the required value to a fuel control adjustment. Although the fuel control adjustment screw was by design meant for shop use only, it is now used for on-wing adjustment. This meant that by monitoring the IFF trend, hot and hung starts and consequent fuel control removals are reduced considerably and related unnecessary engine test runs avoided. Since its introduction more airlines became interested and have requested the engine manufacturer to provide proper means for on-wing adjustment.

Take-off and cruise trends

The take-off and cruise trends are both used for monitoring of engine deterioriation, primarily by checking EGT rise and EGT margin, blade failures, compressor and turbine problems and indicating system errors. The take-off trends is also used to monitor powerlever-alignment which avoids valid crew complaints and allows to neglect invalid crew complaints and save on otherwise necessary follow-on actions.

Gas path analysis

SAS first started using GPA based on testcell data to analyze modular deficiencies on the JT9D engine. After showing positive results KLM installed the same program but to analyze the CF6 engine. After an extensive evaluation and calibration program to determine sensitivity, performance levels and ability to find degraded modules, the program also at KLM is deemed useable to identify problems on preshop tested engines.

The function of the test-cell however has always been primarily to verify that an overhauled or repaired engine meets performance requirements. The identification of modules degraded below limits should therefore preferably occur on-wing such that an engine's work scope can be predicted prior to shop entry.

SAS and KLM has therefore decided to develop the necessary procedures and know how with GPA based on AIDS recorded data.

SAS has started with JT9D-7 engines installed in Boeing 747 while KLM will analyze CF6 engines installed in DC-10. The JT9D program will use only partly instrumented engines while the CF6-DC10 will be fully instrumented. Future aircrafts within KLM, SAS and SWR will always be fully instrumented and in particular the A310 with also a PMUX, presently the only one specified with PMUX, will already from the beginning be monitored by programs capable of modular performance analysis.

Table 5 shows the parameters used in the presently ongoing GPA programs. As can be seen the SAS JT9D-7 GPA uses the least number of parameters and there fore also has the least capability. This program however has advanced the most and a discussion showing some results follows. Because of the small number of parameters that are available to describe the engine operating characteristics, some assumptions have been necessary to do on the modular deterioration that is analyzed. The assumptions are a fixed ratio between change in efficiency and air pumping capacity on the compressor modules and also both the FAN and the LPC are treated as one module. The main disadvantage with the hard coupling between efficiency and air pumping capacity is expected to be seen in the HPC where the front stator vane stages are variable and changes in pumping capacity might be induced this way.

Figure 12 shows the variation in ambient conditions under which data is collected for GPA. Each datapoint being used is a stable frame that has been recorded by the airborne system. The measurements are reduced to sea level static and corrected for effects of Reynolds number, engine service bleed and the offset initially found in the actual installation position. This the corrected value is compared to a fleet average baseline and the percentage difference is calculated. This difference known as "gross delta" is first used to look for apparent sensor errors. If the datapoint is deemed erroneous an appropriate message will be issued and no further analysis is done. The accepted datapoints are used for further analysis.

Figure 13 shows one month worth of data in terms of gross deltas. The result when using each individual gross delta point for analysis is shown in figure 14. As can be seen the scatter is significant and therefore with this combination of sensors and the this way obtained accuracy of gross deltas the result is not accurate enough to correctly analyze module performance based on the data point. The way to get around the problem that is presently used, is that gross-deltas from individual flights are calculated, checked for apparent sensor errors and if found within sensor check limits the gross deltas are passed on to a ten flight average calculation. The gross deltas again in the average calculation will be checked for outliers in a simple correlation analysis. The result from using averaged gross deltas as input to GPA is seen on figure 15.

This particular engine had been installed for several months already at the beginning of this trending, why very limited deterioration is to be expected over the trend period. The 13 trend points now corresponds to 130 flights with stable data, or on this particular route-net approx. 200 cycles.

GPA based on the very limited parameter set used in this trial can not replace pre-shop tests of engines. It gives however additional valuable information on top of the normal trending and will be further studied for use in our preventive removal concept.

LAP, Life Accounting Program

This program is used to bookkeep the amount of damage on critical parts based on actual engine performance and routes flown.

The High Pressure Turbine airfoils on the JT9D-7 are amongst the most critical parts in that engine and are deemed possible to be modelled accurate enough for an analysis. The basic program, written bij PWS, uses precalculated severity factors for each mission and actual AIDS data from each flight to define engine performance levels and routes flown.

The actual life consumption depends upon the mission and the performance status of the engine. The mission is described by a sverity factor that has been precalculated by a Mission Analysis Program using statistical data. Each citypair has several severity factors that varies with respect to season of the year and actual failure mode accounted for, see table 3.

The reason for useage of precalculated statistical severity factors is, that the KSSU airborne 747 AIDS program at the time of specification was not defined to collect mission analysis/life accounting data.

The following failure modes are referred to in the program.

Nozzle Guide Vane crack	- NGV
1st blade creep-fatigue	- 1 BCF
1st blade oxidation corrosion	- 1 BOC
2nd vane deflection	- 2V
2nd blade creep	- 2B

The 1BOC is the only life useage that can be reset by repair e g recoating. All other failure modes refer to life useage that is incremented at each flight throughout the service life of the part.

A typical output generated on a monthly basis is shown on table 4 where the percentage life used is shown for each failure mode. 100 means that expected service life is completely used up.

Experience

The most critical part is 1st blade and therefore, the experience on LAP-life compared to actual failures non-failures is shown in figure 11. A curve ending with F means failure and FO means failure due to overtemperature or where also overtemperature has been confirmed. As shown by the graph there is a good correlation between actual failures and 100% life used for IBCF. The weak point with this program is that statistical missions are used instead of actual. Missions significantly deviating from nominal as well as engine exceedances for example, higher temperatures than normal during take-off, startup or reverse if encountered is not accounted for.

Autoland verification program

This program produces per aircraft a two-monthly review of Autoland performance. Per line the Autopilot disconnect heights, ILS tracking quality, wind at 100 ft, touch-down dispersion and touch-down maximum g-loads are presented. For the total fleet a two-monthly statistical performance review is presented. The program is used to demonstrate an acceptable Autoland success rate to the authorities and keep control over the maintenance of the Autoland system.

747 APU monitoring

The AIDS system allows to apply a very effective means of health monitoring to the Auxiliary Power Unit. The groundbased computer monitors acceleration time, EGT peak and rotor speed at peak EGT, airduct pressure during airconditioning system operation with 3 packs and EGT at no-load condition. This program provides indication of and/or clues to mechanical problems, starting problems, airleaks, compressor and turbine inefficiencies.

747/DC-10 aircraft structure lifecycle programs

Since many years KLM collects AIDS recorded data for assessment of service load experience. Results allow comparison to Boeing's fatigue integrity program with the objective to compare the severity and schedule structural inspections on this basis.

Studies on the recorded data also revealed that changes in pressurisation procedures would extend the life of the pressurised structure.

TROUBLE AND INCIDENT ANALYSIS

In reference (2) the analysis and monitoring of JT9D starting problems and the analysis of JT9D auto-accelerations was presented with the cures.

Since that presentation the CF6 compressor stall problem has been solved. The total story is as follows:

CF6 compressor stalls

Although the KSSU CF6 compressor stall-rate reached a low level of 0.06 per 1000 engine hours, the nature of this problem urged to aim for elimination. The major reason is that stalls can occur in critical phases of the flight and thus might endanger the safety of the flight or comfort of the passengers. Several of the experienced CF6 compressor stalls in the winter period of 1979/1980 occurred at the moment the airplane entered a rainshower (fig. 3). Apparently the compressor inlet temperature (cit), measured at the high pressure compressor inlet, drops at constant N2 rotor speed and constant total air temperature, causing the variable stator vane (vsv) to move with the ultimate result that the N1 rotor speed increases at constant N2, causing some individual engines to stall.

First action was to monitor N1 vs N2 to avoid an N1/N2 matching critical to stall. At the same time the study and analysis of all AIDS recorded compressor stalls by a group of specialists was performed with the objective to ultimately eliminate in-flight stalls.

The studies resulted in two actions:

First : Protective rainshields around the CIT sensors were installed figure 4.
Second : In the testcell the Variable Stator Vane (VSV) schedule was adjusted to the more closed position figure 5.

By these actions the engine stall-rate started to drop significantly as can be seen in figure 6.

Today CF6-50 aero stalls are practically eliminated. The cost of aero stalls to the airline were negligable for CF6's with steel compressor casing but amounted to over $ 200 000 each for CF6's with titanium casing. The savings resulting from elimination of aero stalls alone paid for a very substantial part of the AIDS investments if not complete.

It should be noted that all CF6 operators benefit through the AIDS EMS system as used by KLM and the engineering efforts that KLM and other AIDS users put into the task of solving problems like the CF6 compressor stalls.

Flight Technical

Special Flight Technical analysis programs provide means to analyze crew complaints more thoroughly. Programs developed for this purpose are:

- an ILS beam quality check program
- a runway surface analysis program

and - a windshear analysis program

Fuel Consumption Management

In order to ensure accurate flightplan fuel determination KSS uses a computerprogram to monitor the consumption levels per airplane type and per individual airplane. Accounting for consumption levels of individual airplanes allow tighter fuel reserves. In order to more effectively analyze individual high consumers KLM developed a program based on AIDS data that enables engineering to verify effects of maintenance actions on consumption on a short notice.

Figure 8 shows CF6 gas generator curves developed from AIDS recorded data on one flight using a least squares approximation.

It demonstrates the high degree of repeatability achieveable with AIDS recorded data. The maximum deviations of individual data points from the curves are 0,4% corrected fuel flow, 0.13% corrected N2 RPM and 0.05 corrected EPR.

GENERAL ASPECTS

From the examples of the previous paragraphs AIDS appears as a reliable and useful source. Because of its accurate observations, lessons can be learned fast, proper actions can be subsequently applied and cockpit procedures optimized. AIDS also demonstrated on various occasions the ability to observe and report problems outside the observation capability of the crew, it does not conceal human imperfections nor human excellence in performance. Careful treatment of problems where the human factor is involved is a must when disturbance of human relations is to be avoided.

A300/310 AIDS

Development

Ten years of experience with expanded AIDS systems have demonstrated to KLM, SAS and Swissair that the AIDS has matured into an effective engineering tool as predicted. With increasing positive experience it became evident that more effective airborne software was desirable but prohibited by the capacity of the system and the extreme costs of fleet modifications. With the advance of digitalisation of aircraft systems ARINC started to develop new characteristics for these systems known as their 700 series characteristics. In the Boeing 757 and 767 and the Airbus 310 these 700 series digital systems are extensively used. The impact of this development can best be illustrated by comparing the types of KSS AIDS inputs for the 747 and A310:

747 : 210 discretes, 170 analog and 4 digital data busses
A310 : 39 discretes, 49 analog and 38 digital data busses.

Taking advantage of this progress in the application of digital technology, KSSU and the ATLAS European group of airlines, with full cooperation of Airbus Industrie, started to develop an Expanded AIDS for the A310 (ref. 8) based on ARINC 717 (ref. 9). Early 1980 this effort was successfully completed. A block diagram of this system is shown in fig. Subsequently KSSU developed a specification which in more detail specified the desired software functions and specific features derived from KSSU AIDS experience over the years and contracted the system to a major U.S. supplier. In general the increased capacity of the A310, both in terms of parameter inputs and installed software, is used to enhance the AIDS as an engineering tool and expand its troubleshooting capabilities. The relative expansion on parameter inputs partially comes by itself on a digital airplane where most parameters can be sampled from ARINC 429 data busses.

Justification

As previously stated AIDS proved to be an effective engineering tool and provided to KSS an ample return on investments.

Of course the 747 AIDS was not an optimum system compared to the possibilities and the available experience of today. Therefore applying the lessons learned to the A310 AIDS application will result in a still more cost effective system. The conditions have also changed, c.q. the amount of sensor wiring in the airplane has been decreased compared to the 747 and DC-10 AIDS and the capacity of the electronics increased drastically with the result that the costs of a complete installed system is less than of its predecessors.

Translating the investments to costs per flighthour and assuming a reasonable aircraft utilisation these costs will rougly amount to $ 10.- per flighthour. The total costs will double when the AIDS operating costs are added.

A KSS return on investment study for the A310 AIDS did not produce a homogeneous result between KSS partners because there were several differences in estimated savings per individual program or different emphasis on values of benefits.

The ultimate conclusion as derived from past experience can therefore best be presented schematically. Figure 8 shows that the level of quantifyable savings will more than balance the AIDS operating costs.

Characteristics of the KSS A310 AIDS

The control of the recording, printing and display functions is performed by the Data Management Unit (fig. 9). In this unit an Intel 8086 16 bit microprocessor is installed to perform the required functions. The memory comprises 58 K bytes PROM, 18 K bytes RAM, 29 K bytes protected RAM and 39 K bytes EAROM.

Depending on the flight mode the DMU commands continuous recording or selective recording.

All data that is to be recorded passes a 20 second delay buffer such that at detection of specific events always 20 seconds pre-event data is available on the tape-cassette. 75% of the cassette-tape capacity is used for routine recording and the remaining 25% is programmable via the Control Display Unit (CDU). This feature provides to engineering a tool to analyse and solve persistent problems.

The on-board printer can be used by the crew for hard copy engine data but its primary purpose is to provide maintenance with all necessary information. For this reason all maintenance prints are stored during flight and a light on the CDU will inform the maintenance crew that exceedance reports are stored in the DMU memory. In case of specific events as defined in the program, 20 seconds of data prior and 20 seconds of data after the event will be stored and can be recalled by the maintenance engineer using the printer. The memory section used for this feature is called the replay buffer.

From the replay buffer the maintenance engineer can select "canned" sets of parameters prividing a second by second listing of the event occurrance.

For the objectives set for the EMS part of the program it became necessary to provide additional sensors on the engines. KSS and ATLAS in close cooperation with Airbus Industrie and the engine manufacturers succeeded to specify a Powerplant Multiplexer (PMUX) as standard part of an A310 Expanded AIDS.

This PMUX multiplexes temperature and pressure signals, combines these with the output of the Electronic Engine Control (EEC) or Power Management Control (PMC) and sends all this information with the engine serial number via an ARINC 429 dataline to the DMU. This improvement ensures a tighter maintenance control on the quality level of those inputs not monitored by the flightcrew.

A310 ENGINE MONITORING

KSSU formed a team of engine monitoring experts to participate in the specification work on the A310 AIDS. This group being able to take advantage of experience with already existing programs has defined a system incorporating several new features that have never before been available.

Program functions

New functions

Two of the new program functions namely the "history buffer" and the "replay memory" are briefly described already above. One other is known as "stored prints" and works such that the printer does not print in real time, with some very few exceptions, but data that shall be printed is stored in a "print buffer" until a special request is made. There is capacity for storeage of 11 prints with the distribution as defined in table 6

Exceedance Control

The software of course is capable of defining flight modes and to compare selected engine parameters against flight mode related limits throughout the mission.

In case of an exceedance, different actions will be taken. An exceedance can thus cause:

1. Update of exceedance print buffer
2. Recording without 20 sec. pre-event data
3. Recording with 20 sec pre-event data
4. Update of replay memory.

Stable Condition search

The search for stable conditions is, done with a new logic. The method can be described as a window sliding in time over actual and previous data, that are remembered in the computer, looking for stability. Old data is compressed in such a way that it is represented by its average over a 16 sec. period. A maximum of 8 periods will be kept in memory this way. Previously, normally was used a method that stored a reference sample to which actual data was compared over a predefined stable time period or until out of stability occurred leading to a new sample being set.

If a stable period occurs that is not considerably longer, than the predefined stable time period, it is very likely so, that the old logic should not be able to find it. The A300/310 is a short haul aircraft and the time during cruise is so short that an improved search method for stable data was needed.

Divergence monitoring

Another new feature will be the "EGT divergence monitoring" (EDM). The purpose of EDM is to have a method that immediately can recognize a sudden gas path damage through its effect on monitored engine parameters. The influence coefficients for a typical twinspool engine show that regardles of performance deterioration, except for fan flow capacity any gas path damage will affect EGT in an increased direction. Therefore during specified conditions EGT of the two engines are compared.

Both engines are operating in the same ambient conditions so that no correction for that has to be done. One engine is corrected for its offset in thrust setting to the reference engine and the resulting difference in EGT between the two engines is compared to a reference difference established first flight every day. If the difference between actual EGT delta and reference EGT delta exceeds a certain value, the one engine with the increased EGT is automatically pointed out as the unhealthy one by the AIDS system.

Recording Control General

Continuous recording takes place in the following flight modes, engine start, take-off and approach landing. Selective recording is performed in the other flight modes, which means one frame every 100 sec. will be recorded.

Exceedance recording

20 sec. of pre exceedance data and additional data min 20 sec, max 120 sec. or until the exceedance is passed is recorded.

Corner points

Corner points are recorded to better define the mission. The corner points are used in groundbased programs for mission analysis with respect to life accounting on critical parts and refined cycle counting on life limited parts. These points are defined as end of climb or start of descent.

Recording of selected frames for oil consumption monitoring

Either during taxi before and after the flight or prior to engine start and after shut down, data can be recorded for the purpose of oil consumption monitoring.

Recording of stable data

Above a certain altitude, mach number and in cruise, stable conditions are continuously searched for. When stable conditions are found data is automatically recorded.

Recording of APU

Every time the APU is started on external or engine power, 16 frames worth of data will be recorded.

Other planned A310 AIDS applications

As for the current KSSU wide-body aircraft the A310 AIDS will also be used for:

- verification of satisfactory autoland system operation
- trouble and incident analysis
- assessment of service load experience

and the monitoring of:

- the condition of the auxiliary power unit
- the braking and anti-skid system
- aircraft performance deterioration
- safety limit exceedances

A310 AIDS ground system

The system proposed for KLM is depicted in figure 10. It shows again the emphasis KSS lays on the function of AIDS as an engineering tool. The AIDS data as recorded on a cassette continuously will update a data-base in the main EDP center where in paralell also data is stored providing information on crew complaints, maintenance actions, etc. This EMS data base provides periodic trend reports, status reports and automatic exceedance reports and is via terminals accessible by line maintenance and engineering

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EMS PARAMETERS MONITORED ON KSS AIRCRAFT

AIRPLANE	BOEING 747		DC 10	AIRBUS A310
ENGINE	P&W JT9D	GE CF6-50E	GE CF6-50C	GE CF6-80A1
ENGINE PERFORMANCE PARAMETERS:				
FAN ROTOR SPEED	X	X	X	X
CORE ROTOR SPEED	X	X	X	X
EXHAUST GAS TEMPERATURE (EGT)	X	X	X	X
FUEL FLOW	X	X	X	X
LPC DISCHARGE PRESSURE	-	-	X	X
LPC DISCHARGE TEMPERATURE	-	-	X	X
HPC DISCHARGE PRESSURE	X	X	X	X
HPC DISCHARGE TEMPERATURE	-	-	X	X
ENGINE PRESSURE RATIO	X	-	-	-
VARIABLE STATOR VANE POS. (VSV)	-	-	X	X
LPT INLET PRESSURE	-	X	X	X
VIBRATION FAN ROTOR	X	X	X	X
VIBRATION CORE ROTOR	X	X	X	X
ENGINE OIL QUANTITY	X	X	X	X
ENGINE OIL PRESSURE	-	-	-	X
ENGINE OIL TEMPERATURE	-	-	-	X
POWER LEVER ANGLE	X	X	X	X
IGNITION	X	X	X	X
FUEL SHUT-OFF VALVE	X	X	X	X
BLEED RELATED PARAMETERS:				
START VALVE POSITION	X	X	X	X
PNEUMATIC BLEED VALVE POSITION	X	X	X	X
ISOLATION VALVES	-	-	X	X
PACK MODE SELECTOR	X	X	X	X
ENGINE INLET ANTI-ICE	X	X	X	X
WING ANTI-ICE	X	X	X	X
VARIABLE BLEED VALVES	-	-	-	X
APU SHUT-OFF VALVE	-	-	X	X
NACELLE TEMPERATURE	X	X	-	X
BLEED PRESSURE	X	X	X	X
BLEED TEMPERATURE	X	X	X	X
AMBIENT PARAMETERS:				
FLIGHT IDENT	X	X	X	X
DATE	X	X	X	X
GMT	X	X	X	X
FLIGHT MODE	X	X	X	X
PRESSURE ALTITUDE	X	X	X	X
TOTAL AIR TEMPERATURE	X	X	X	X
MACH NUMBER	X	X	X	X
STEADY STATE IDENT	X	X	X	X
AUTO THROTTLE ENGAGED	X	X	X	X

TABLE 1

SAMPLE ENGINE DATA PRINT
FROM AIDS ON-BOARD PRINTER

```
-------------------------------------------
          A/C 747B      1  MODE        2
          FLT         688  ALT      6990
          DATE      11.05  CAS        46
          GMT        1734  MACH    *.***
          SCAN       1781  TAT        29
          FLCT       1251
          SCAN     1781
          EPR     1.007 1.012 1.017 1.016
          N1       13.1  23.9  28.0  28.3
          EGT     629.5 451.6 408.8 399.1
          N2       39.9  60.3  63.7  65.0
          FF        153   572   647   635
          VIB I      .0    .0    .1    .0
          VIB T      .2    .1    .3    .3
          BR.P       .2    .2    .3    .9
          WATER       0     0     0     0
          PWRL   -    1     0 -   1 -   2
          PS4      12.4  28.3  37.4  38.1
          APU EGT     460  APU RPM  100.2
          DUCT PR L    30  DUCT PR R   29
          IGN 1       0     0     0     0
          IGN 2       0     0     0     0
          PN.VALVE    0     0     0     0
          OIL T      45    57    85    87
          NACT A    1.6   1.7   1.9   2.0
          NACT B    2.0   1.7   1.7   1.7
          EAI         0     0     0     0
          WAI           0  EPR LIM  1.445
          EPR MODE      2  APU EGTL   900
          EGT L. 649.9 649.9 649.9 649.9
          N1 LIM 104.2 104.2 104.2 104.2
          BR.T     43.6  61.0  88.7  85.1

NOTE: IMPENDING HOT START NUMBER 1 ENGINE
      (AT MEXICO CITY AIRPORT).
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TABLE 2

TABLE 3

SEVERITY FACTORS PER CITY PAIR & FAILURE MODE

city-pair	flt. time	sea-son1	sea-son2	sea-son3	sea-son4	failure mode
AMS FRA	7.9	2169	2371	2898	2616	NGV
AMS FRA	7.9	1240	1656	3410	2089	1BCF
AMS FRA	7.9	0936	1418	3836	2107	1BOC
AMS FRA	7.9	0190	0350	1440	0571	2V
AMS FRA	7.9	7465	8643	11800	8673	2B

TABLE 4

OUTPUT FROM MAP-LAP

PROCESSING DATE 27MAR81
REFERENCE STOMK-R FRANZEN

SORTED BY A/C REG NO

THE FOLLOWING IS A SUMMARY OF THE DAMAGE ACCUMULATED ON EACH PART

INST POS	ENGINE NO	I------------- % LIFE USED -------------I NGV	1BCF	1BOC	2V	2B
DDL1	563074	5 2	6 1	7 3	76 5	3 2
DDL2	662987	18 0	16 0	19 1	16 2	5.9
DDL3	562841	93.3	17 8	7 1	76 6	50 9
DDL4	663067	95.7	37 8	23 9	31 8	23 2
KHA1	562814	95 9	54 1	8 1	83 9	26 5
KHA2	662999	7.3	7 4	9 4	49.7	3 1
KHA3	562750	6 8	63.7	8 6	47 8	39 7
KHA4	562909	8.5	9 0	11 2	76 5	3.9
IGA1	662762	92 3	63 6	2 2	72 4	49 4
IGA2	563073	50 0	62 4	.5	46.4	0 0
IGA3	563079	110 9	23 9	21 5	95 9	67 7
IGA4	562803	96 5	55 9	31 9	52 5	66 5
IGB1	562927	47 1	14 0	7 9	46 9	65 2
IGB2	585637	35 2	25 6	24 9	27.2	11 2
IGB3	562982	95 3	70 7	7 3	40 3	4 1
IGB4	585636	68 2	44 5	9 1	48 2	57 9
BUA1	685616	36 2	18 3	10 2	43 6	36 7
BUA2	663011	90 2	4 3	4 7	49 7	1 9
BUA3	562818	90 2	85 2	.1	95 3	80 1
BUA4	585635	95.2	19 0	16 1	21 7	11 0
BUB1	662754	94 1	87 3	1 9	80 4	71 0
BUB2	562979	79 1	41 9	24 3	32 1	.8
BUB3	662930	91 9	31 5	18 0	54 6	44 5
BUB4	562846	97 1	62 1	8 1	84 1	92 0

TABLE 5

PARAMETERS USED IN KLM.SAS GPA PROGRAM

KLM CF6-DC10	SAS JT9D-B747
N1	N1
N2	N2
WF	WF
EGT	EGT
PS2C	PS4
TT2C	EPR
PS3	
TT3	
PT5.4	
VSV *	

* VSV ON SAMPLE ENGINE ONLY

TABLE 6

PRINT FORMATS / NAMES

COMPARISON REPORT	- PRINT/EVENT	1
	- STABLE	2
	- EXCEEDANCE	2
	- TAKE OFF	1
	- CDU REQUESTED	
TAKE OFF TREND REPORT		1
CRUISE TREND REPORT		1
FAILED ENGINE START REPORT		1
MAINTENANCE REPORT		1
LOAD/FLIGHT CONTROL REPORT		1

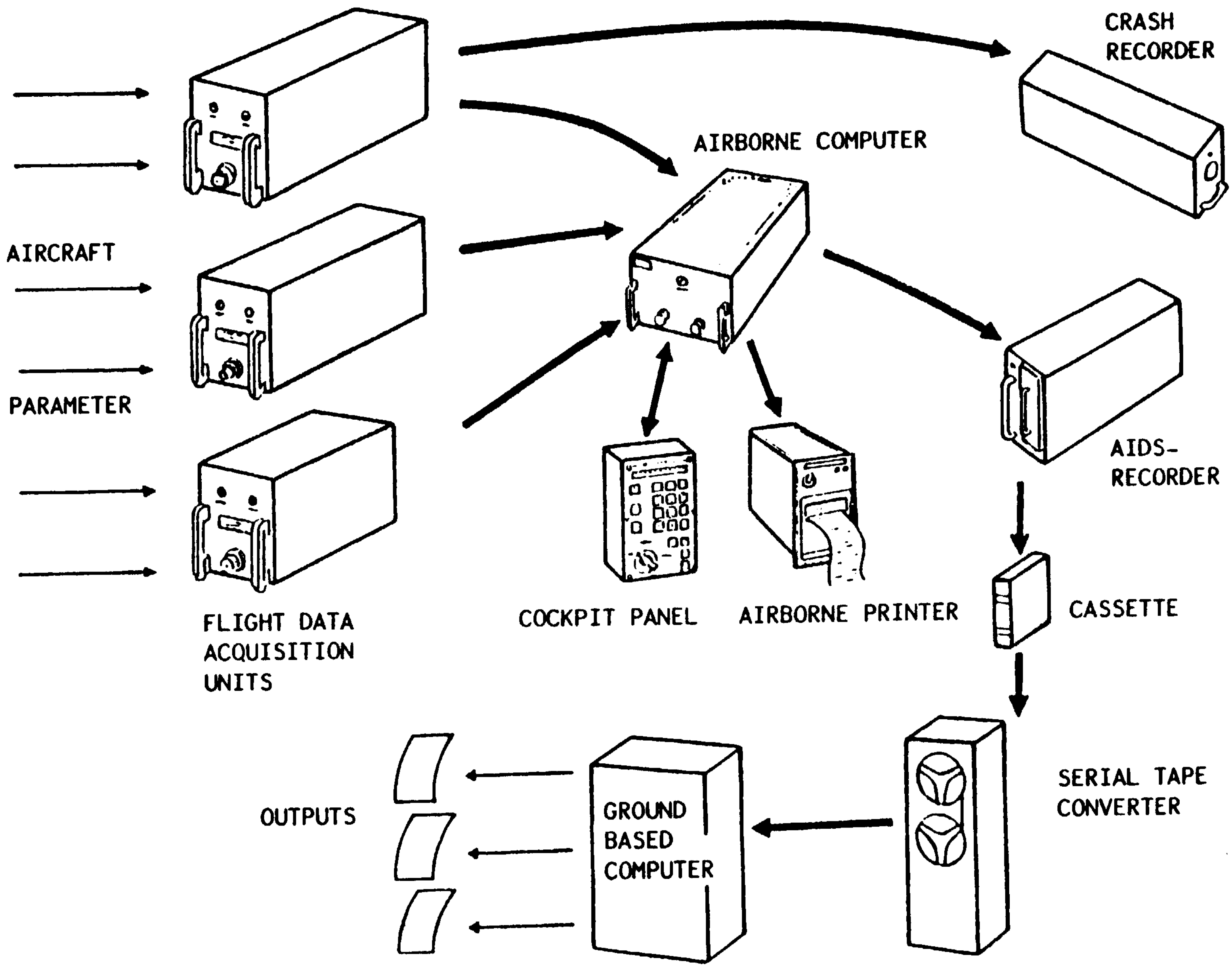


FIG. 1 AIDS SYSTEM AS INSTALLED IN KSS 747 AND DC-10 AIRCRAFT

ENGINE ANALYSIS 747B A/C PH-BUB POS 2 ENGINE 662879 INSTALLED 10JAN. 81 VERSION 30 PRINT DATE 7 APR 81 PAGE 4

OUTPUT TYPE : DAILY

FLIGHT EXCEEDANCES

NO EXCEEDANCES

START TREND

DAY	GMT	FLT	DEP/ARR	T20	T10	T50	BLP	BLT	O/T	PALT	TAT	APUN	EGTP	N1P	N2P	IFF	SFF	BLV 1234
302	723	845	CMB/SIN	17	5	16	29.3	155	91	80	48	101.1	533	14.0	46.2	2460	705	0101
302	1329	845	SIN/MEB	19	6	16	35.8	160	35	90	23	101.0	458	14.0	46.6	376	744	0100
302	2215	845	MEB/SYD	15	5	15	33.7	143	78	483	19	101.0	487	13.9	47.4	345	717	0100
402	455	846	SYD/MEB	14	6	15	35.7	144	56	222	29	100.8	474	14.2	47.2	1555	726	0100
403	707	846	/	***	0	0	35.8	151	91	526	21	100.8	474	14.2	47.2	****	****	0100
202	1859	845	SPL/DXB	18	12	16	36.2	141	12	-333	9	101.2	459	14.5	47.7	415	825	0100
302	217	845	DXB/	***	10	14	33.6	148	85	-73	17	101.1	460	13.9	46.0	349	737	0100
302	723	845	CMB/SIN	17	5	16	29.3	155	91	80	48	101.1	533	14.0	46.2	2460	705	0101
302	1329	845	SIN/MEB	19	6	16	35.8	160	35	90	23	101.0	458	14.0	46.6	376	744	0100
302	2215	845	MEB/SYD	15	5	15	33.7	143	78	483	19	101.0	487	13.9	47.4	345	717	0100
402	455	846	SYD/MEB	14	6	15	35.7	144	56	222	29	100.8	474	14.2	47.2	1555	726	0100
403	707	846	/	***	0	0	35.8	151	91	526	21	100.8	474	14.2	47.2	****	****	0100
304	1241	641	SPL/JFK	19	6	***	35.7	142	16	-296	13	99.6	469	22.1	58.6	397	762	0101
304	2307	642	JFK/SPL	16	7	15	36.3	143	58	-61	12	100.1	435	13.0	46.0	338	735	0101
504	1210	611	SPL/ORD	16	5	15	37.5	140	42	-285	13	99.6	433	13.9	46.9	401	768	0101
504	2241	612	ORD/SPL	15	5	15	36.6	134	61	488	6	99.6	435	14.4	47.5	329	755	0101
404	1227	677	SPL/YMX	15	6	16	37.7	134	30	-350	12	99.6	424	14.4	47.1	385	793	0101
404	2336	678	YYZ/YMX	16	5	15	35.2	138	72	835	16	99.6	463	13.5	46.4	331	689	0110
304	1241	641	SPL/JFK	19	6	***	35.7	142	16	-296	13	99.6	469	22.1	58.6	397	762	0101
304	2307	642	JFK/SPL	16	7	15	36.3	143	58	-61	12	100.1	435	13.0	46.0	338	735	0101

a

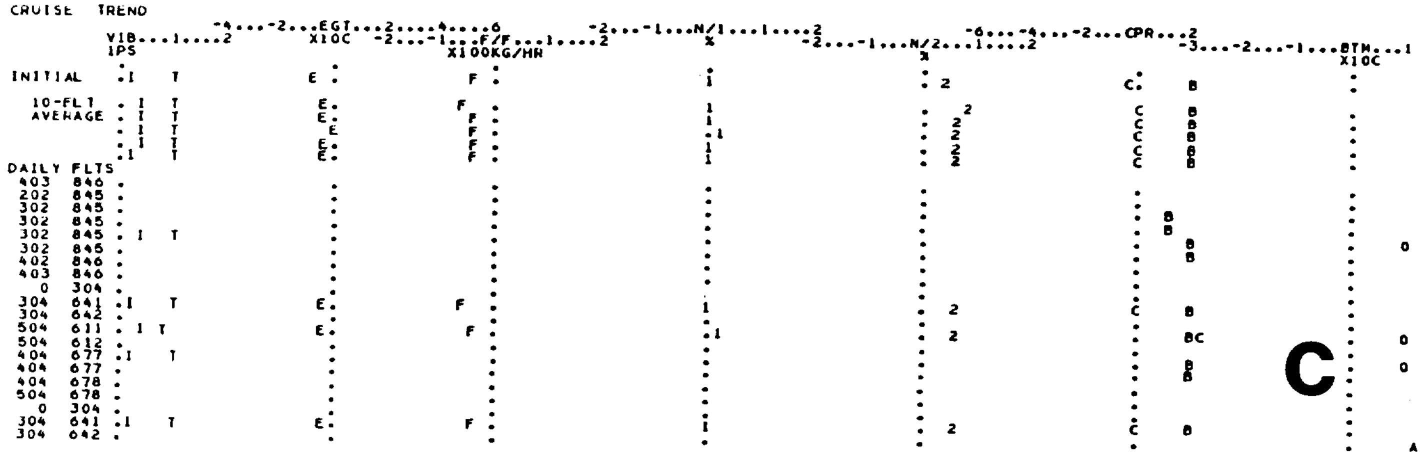
TAKE-OFF TREND

TAKE-OFF PERFORMANCE

NORMAL NUMBER OF A/C PACKS IS 2

DAY	GMT	SCAN	FLT	DEP/ARR	EPR	EPRL	EGT	F/F	N1	N2	PS4	BPR	O/T	I-VIB-T	THP	PALT	TAT	CAS	TTO	TTA	A-NT-B	ACP 123	BLV	EAI	WI	IGN
304	2321	1060	642	JFK/SPL	1.411	1.42	818	7664	90.4	94.1	291.7	4.9	91	0.6 2.3	69	-56	11	125	0.0	0	1.6 1.8	111	1	0	0	B
504	1223	1897	611	SPL/ORD	1.427	1.44	841	8135	91.0	93.8	298.5	4.8	84	0.6 2.1	72	-275	8	129	0.0	0	1.7 1.9	111	1	1	0	B
504	2251	3599	612	ORD/SPL	1.378	1.39	781	7032	87.7	92.7	276.4	4.7	88	0.5 1.7	63	491	6	127	0.0	0	1.6 1.9	111	1	0	0	B
404	1243	1717	677	SPL/YMX	1.378	1.38	802	7377	88.0	92.4	280.9	4.7	82	0.5 2.3	64	-335	7	121	0.0	0	1.7 1.9	111	1	1	0	B
404	2039	2242	677	YMX/YYZ	1.363	1.39	823	7101	89.6	95.2	270.5	4.0	93	0.5 2.2	71	524	22	134	0.0	0	1.6 1.8	111	1	0	0	B
404	2347	1512	678	YYZ/YMX	1.364	1.38	802	6917	88.6	94.1	266.7	4.5	92	0.6 2.9	66	850	15	124	0.0	0	1.6 1.8	111	1	0	0	B
504	146	657	678	YMX/SPL	1.371	1.38	813	7104	89.3	94.5	272.9	4.5	92	0.4 2.7	67	469	17	125	0.0	0	1.6 1.8	111	1	0	0	B
0			304	XXX/				NO	TO-DATA																	
304	1257	940	641	SPL/JFK	1.410	1.41	818	7710	90.5	94.1	293.8	5.0	84	0.6 2.4	68	-281	10	134	0.0	0	1.6 1.9	111	1	0	0	B
304	2321	1060	642	JFK/SPL	1.411	1.42	818	7664	90.4	94.1	291.7	4.9	91	0.6 2.3	69	-56	11	125	0.0	0	1.6 1.8	111	1	0	0	B

CRUISE TREND



CRUISE PERFORMANCE

NORMAL NUMBER OF A/C PACKS IS 2

DAY	GMT	SCAN	FLT	DEP/ARR	EPR	EPRL	EGT	FF	N1	N2	PS4	O/T	I-VIB-T	THP	PALT	TAT	CAS	MACH	A-NT-B	ACP 123		AIR-BREATHER-TEMP MARGIN ABT	EPR	TAT	O/T	EBI ALG IVN
304			642	JFK/SPL	NO STABILIZED FRAME																	NO BTM DATA				
504	1538	1600	611	SPL/ORD	1.246	1.43	668	2713	86	87	121	93	0.5 1.0	36	309	-19	306	.822	1.6 1.8	101		148	1.361	2	94	011
504			612	ORD/SPL	NO STABILIZED FRAME																	NO BTM DATA				
404	1314	3600	677	SPL/YMX	1.309	1.43	692	2931	87	88	127	93	0.3 1.1	41	310	-19	304	.819	1.7 1.8	111	ABN	151	1.340	8	94	010
404			677	YMX/YYZ	NO STABILIZED FRAME																	153	1.363	15	94	
404			678	YYZ/YMX	NO STABILIZED FRAME																	NO BTM DATA				
504			678	YMX/SPL	NO STABILIZED FRAME																	NO BTM DATA				
0			304	XXX/	NO STABILIZED FRAME																	NO BTM DATA				
304	1334	3200	641	SPL/JFK	1.340	1.50	711	3074	89	89	131	93	0.3 1.1	42	310	-15	311	.836	1.6 1.8	101		154	1.339	14	94	010
304			642	JFK/SPL	NO STABILIZED FRAME																	NO BTM DATA				

FIG. 2 AIDS LONG TERM TREND JT9D ENGINE

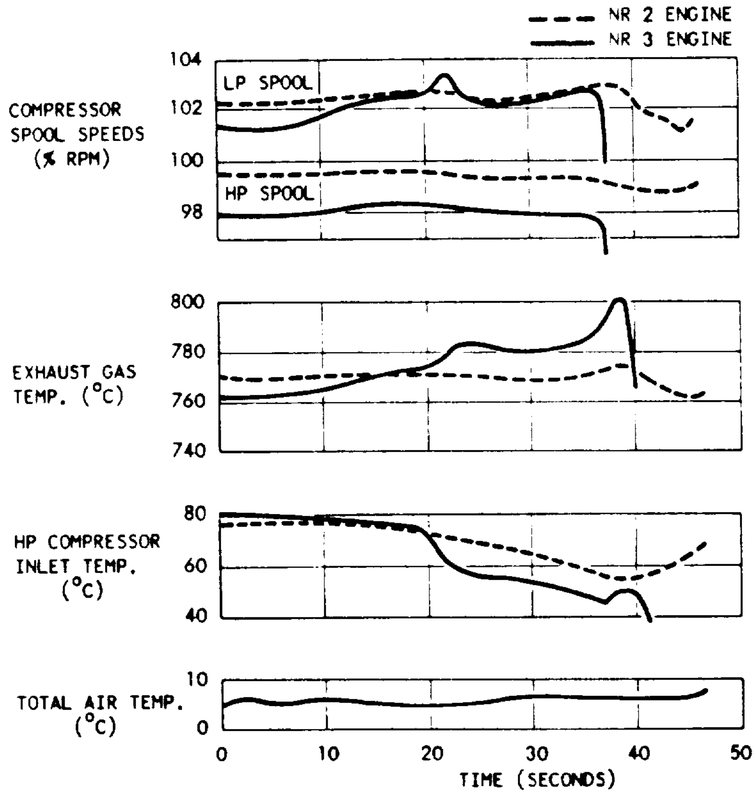
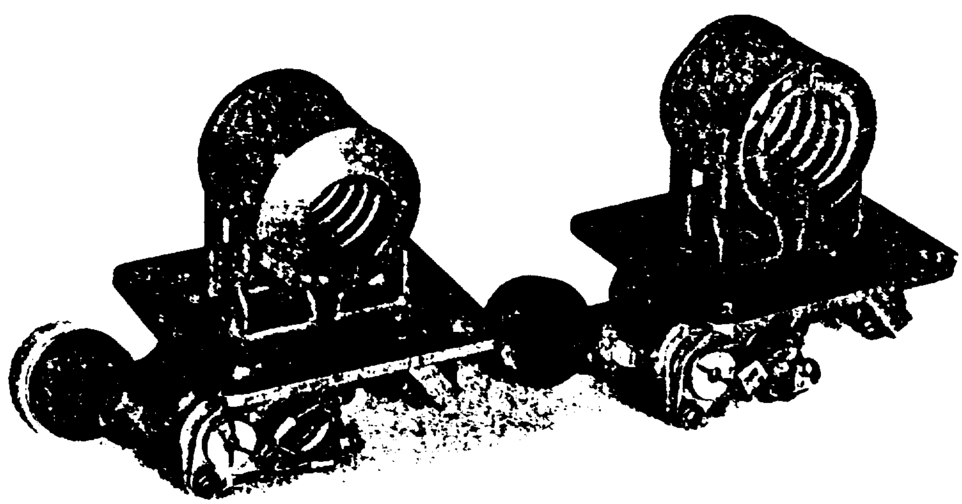


FIG. 3 AIDS TRACE OF COMPRESSOR STALL ON A DC-10 AIRPLANE (CF6-50)

CIT Sensor



With Rainshield **Standard Sensor**

FIG. 4 CIT SENSOR

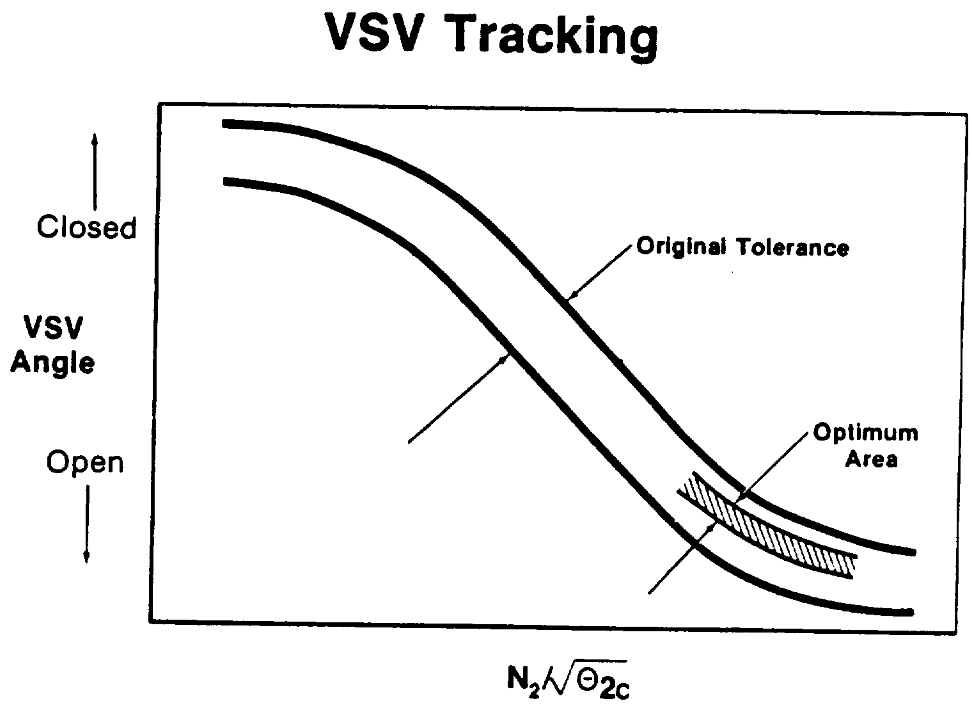


FIG. 5 VSV TRACKING

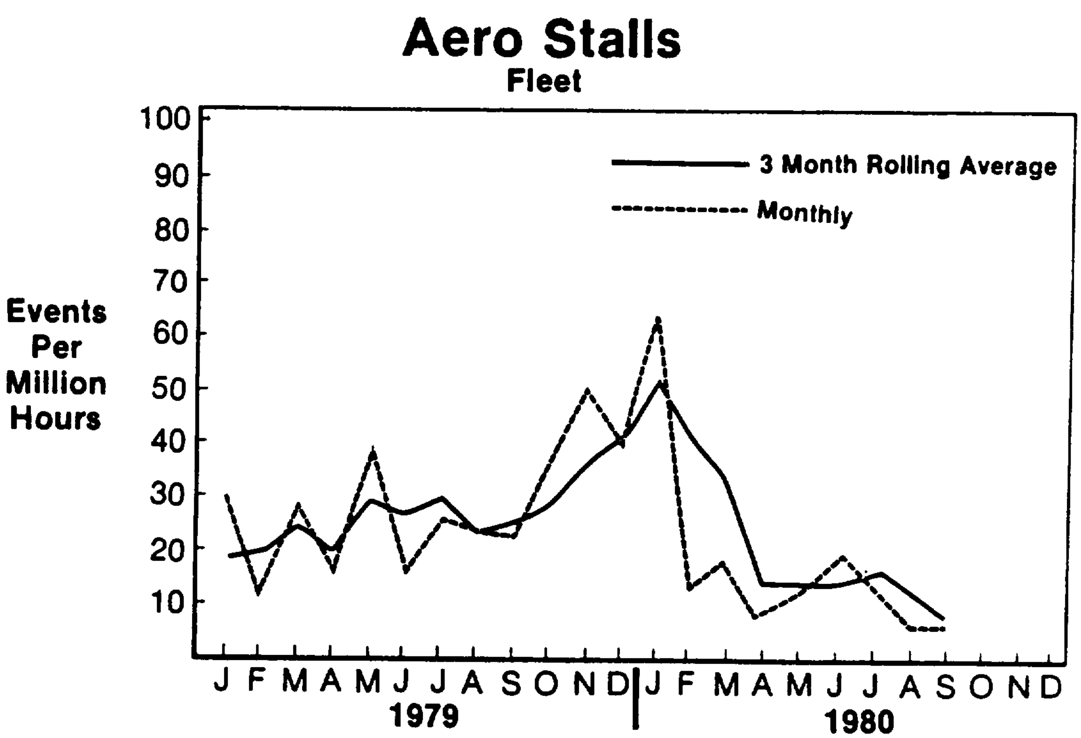


FIG. 6 CF6 AERO STALLS

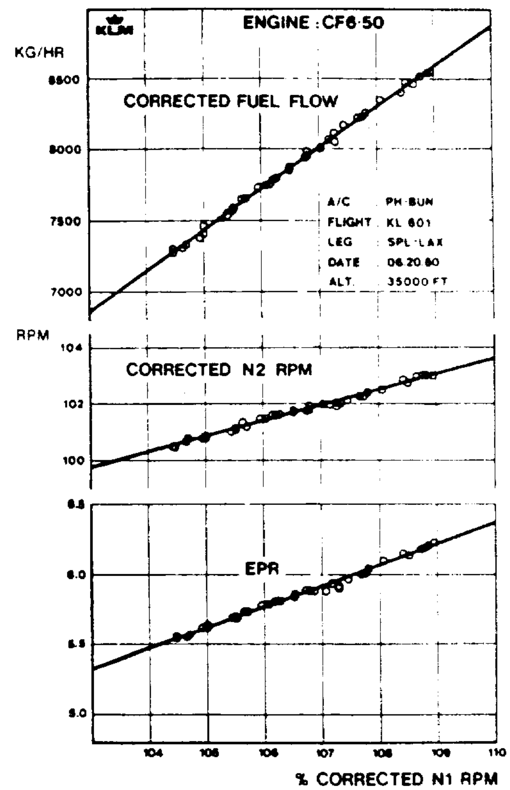


FIG. 7 AIDS CF6 GAS GENERATOR CURVES

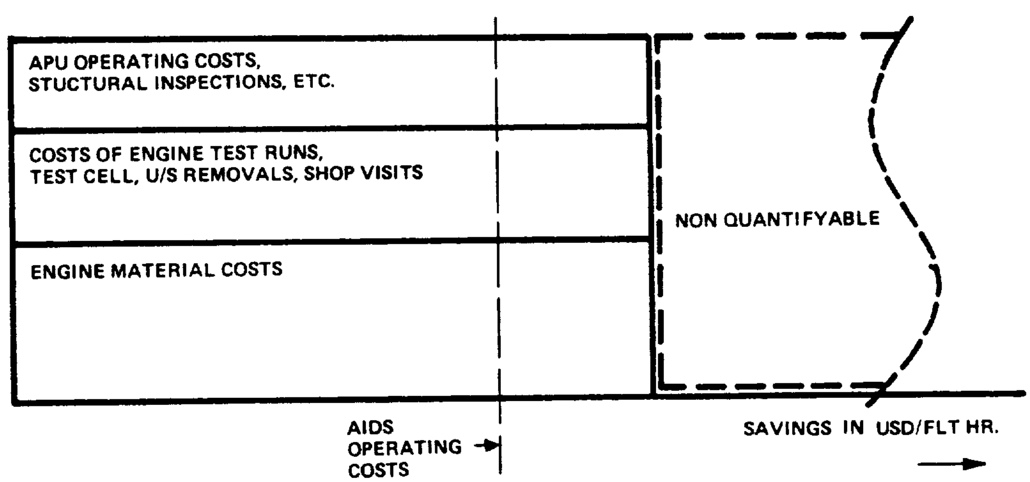


FIG. 8 PROJECTED A310 AIDS RETURN ON INVESTMENT

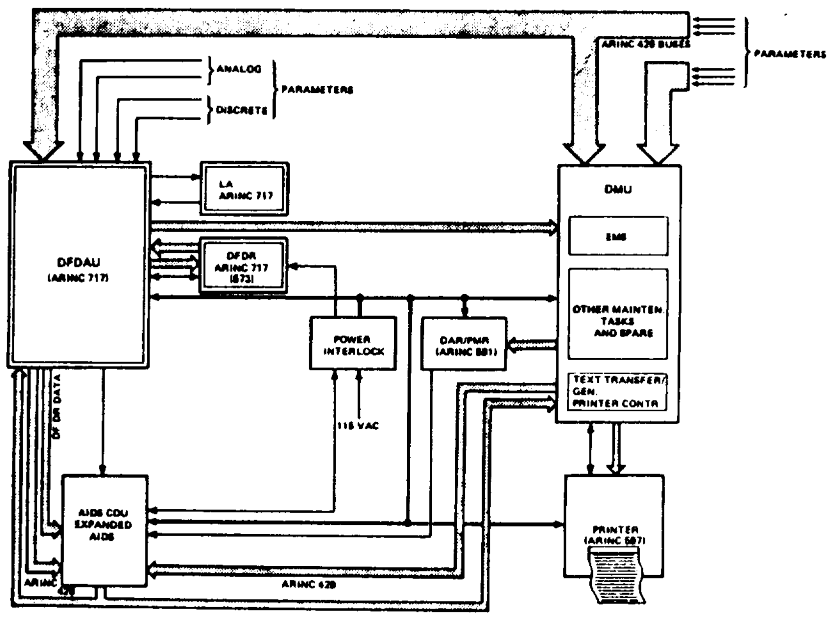


FIG. 9 AIRBUS A310 AIDS SYSTEM DIAGRAM

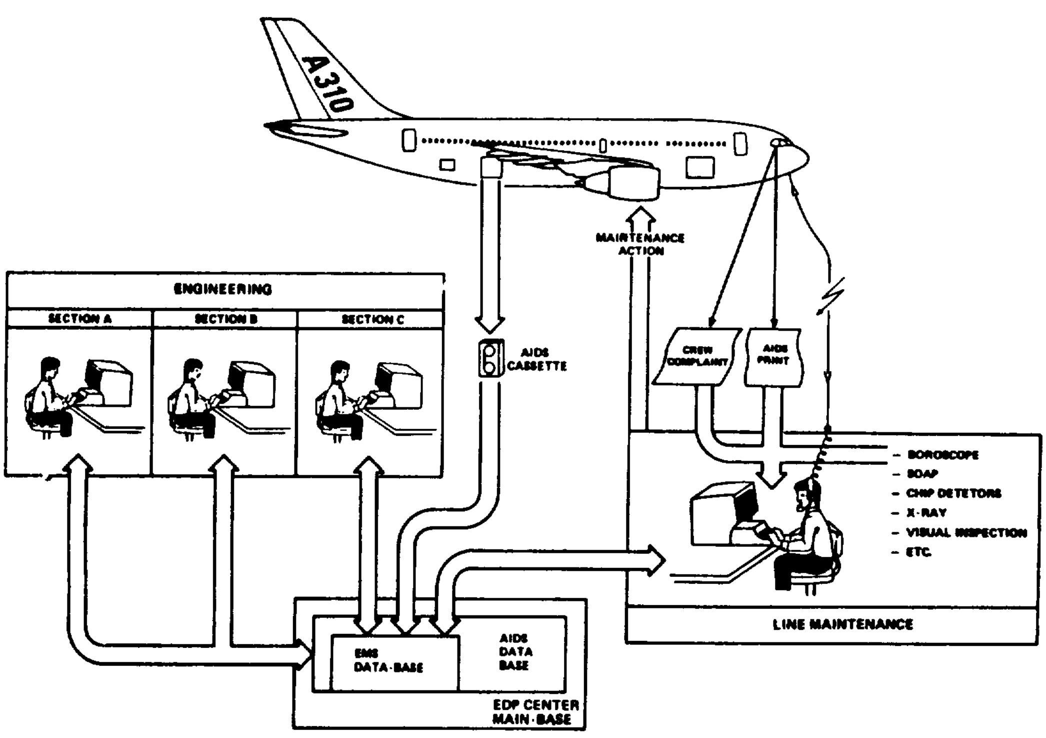


FIG. 10 A310 AIDS GROUND SYSTEM

LIFE USED FOR FIRST TURBINE BLADE

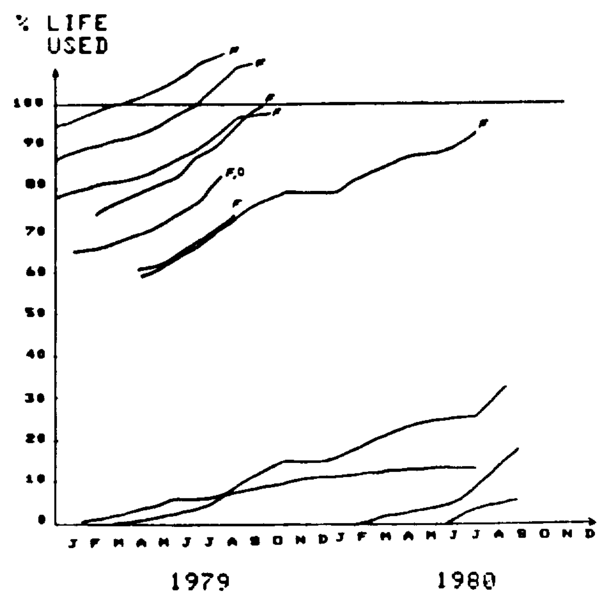


FIG 11

AMBIENT CONDITIONS

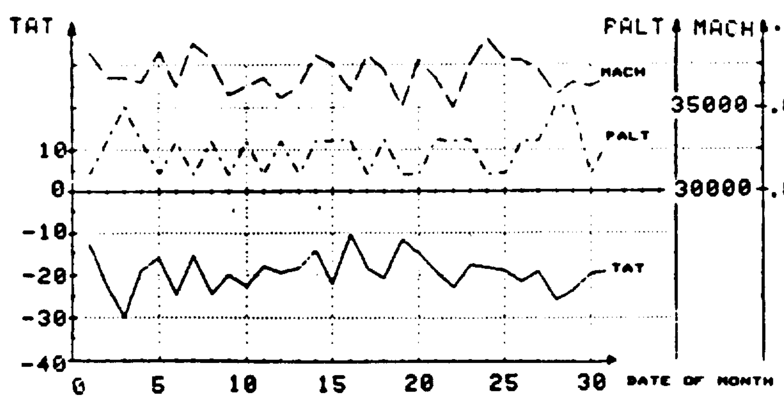


FIG 12

% DEVIATION FROM BASE 'GROSS DELTA'

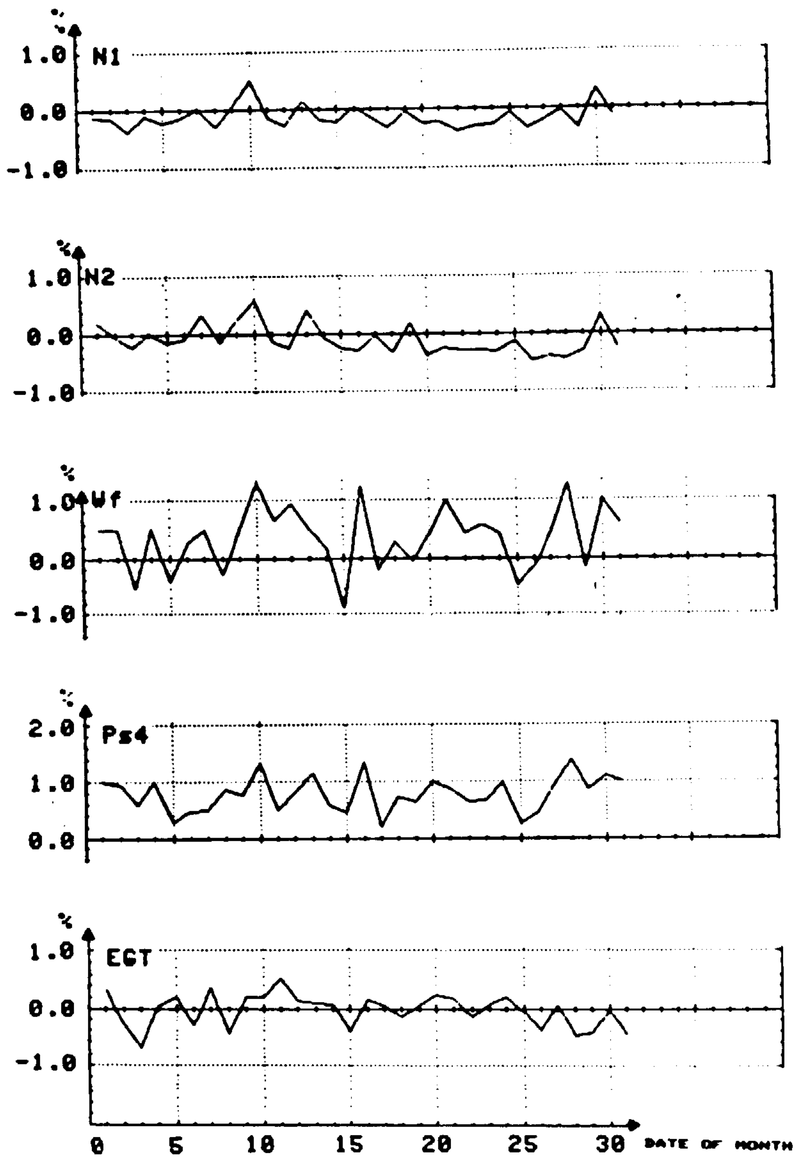


FIG 13

CALCULATED MODULAR PERFORMANCE DEVIATION

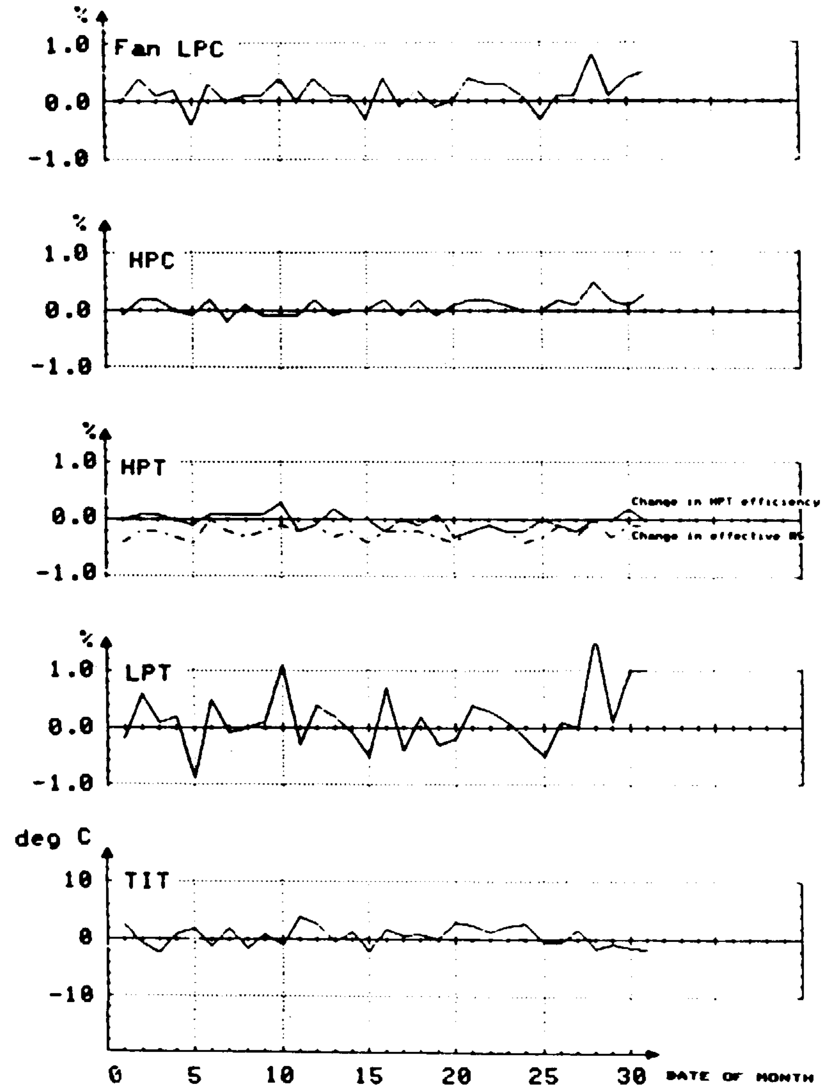


FIG 14

CALCULATED MODULAR PERFORMANCE DEVIATION

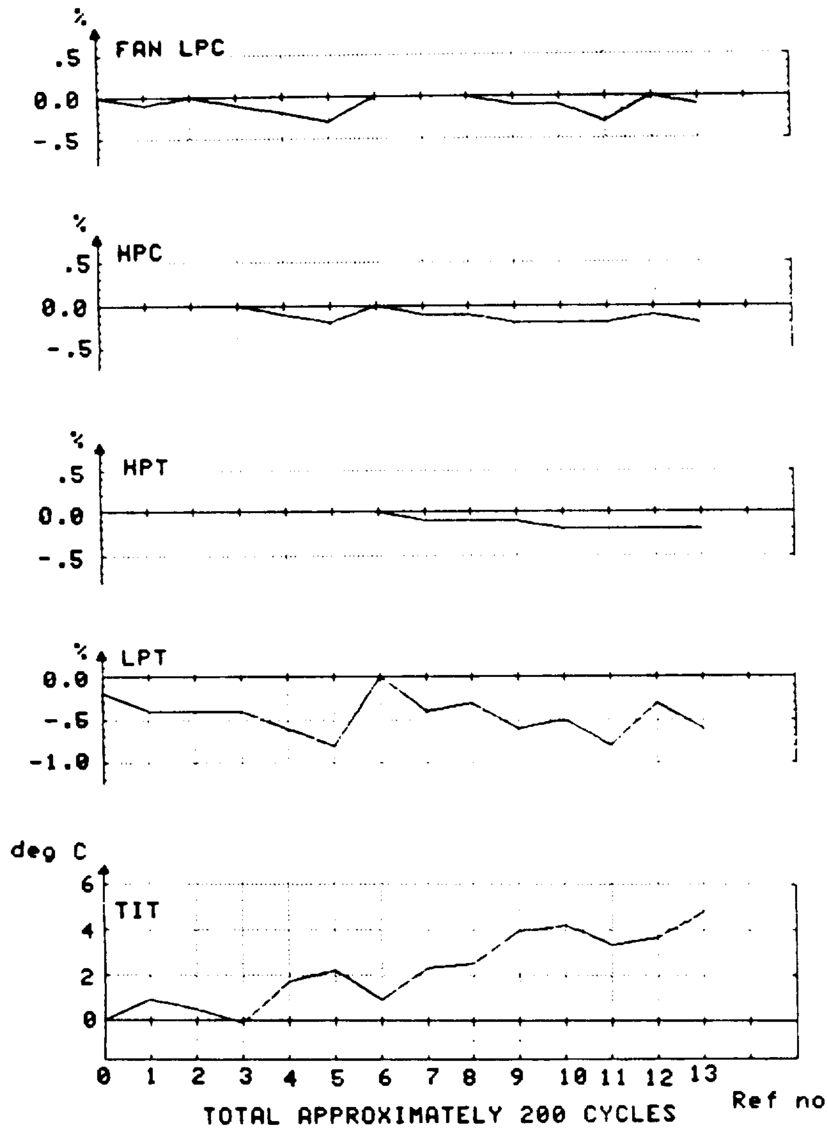


FIG 15