referring to FIG. 23, the 0.56 density index line is followed by the set of arrows 502. The 240 horsepower curved line is designated by the reference numeral 504. These two lines intersect at the point 506. Now, from this intersection point, the ideal normalized fuel flow, engine temperature, and engine speed may be calculated. More specifically, the fuel flow lines run diagonally from upper left to lower right in FIG. 23, and by extending from point 506 upwardly and to the left parallel with the fuel flow lines, the arrows 508 lead us to a indication of a fuel flow figure. Extending upwardly and to the left along the line indicated by the arrows 508, it may be seen that the normalized fuel flow for the conditions provides a fuel flow of slightly less than 170 pounds per hour or approximately 168 pounds per hour. This figure is compared with the actual fuel flow as measured at input 182 in FIG. 9, and the variance is plotted at the proper date at which the reading was taken, in the left-hand plot of FIG. 24. Incidentally, in FIG. 24, successive entries may be taken on successive days of operation, or successive increments such as five-hour increments of run time of the turbine engine under consideration. The actual numbers which appear to the left are the figures represented by the lines on the plot.

Returning to FIG. 23, the horizontal line 510, accompanies by the arrows, show us the readings on the tamperature and engine speed scales, indicating the optimum engine operating temperature and engine speed, for a new engine. More specifically, the engine temperature appears to be approximately 622 or 623 degrees C., and the engine speed appears to be approximately 91.5 percent of the maximum rated speed. As in the case of the normalized fuel flow figure, these engine speed and temperature figures are compared with the actual engine speed and temperature figures as provided by the sensors at inputs as shown to the left in FIG. 9, and the variances are plotted as indicated in FIG. 24.

FIG. 22 indicates the steps involved in trend monitoring, performed "manually" or graphically, and they start with the calculation of the air density from the temperature and altitude, as indicated by block 522; and the shaft horsepower is calculated from the torque inputs and the speed of the turbine fan or the propeller in a turbo-prop engine, as indicated by block 524 in FIG. 22. The next step is to calculate the normalized engine performance in terms of fuel flow, temperature and turbine speed (gas generator Ng), as indicated by the block 526, with an air speed correction being included as indicated by the block 528. The comparison with the actual fuel flow, temperature, and speed, and the calculation of the differences in terms of the actual temperature or the percentage variance, is indicated by the block 530 in FIG. 22. The variances are then stored in the computer memory, along with an indication of the time at which the trend monitoring data was recorded, and this is indicated by the block 532. Block 534 indicates the withdrawal from storage of the variance history on command, and block 536 shows the plotting of the variances with time, as indicated in FIG. 23; alternatively, the variance history may be printed out.

In the foregoing discussion, the steps for determining the normalized fuel flow, temperature and engine speed, given the density index and the horsepower were shown, on a graphical basis. In addition, these factors may be calculated by formulas which are available for each aircraft, and are provided by the aircraft manufacturer. Of course, these formulae, although similar, differ for each type of aircraft and aircraft engine. Instead of manually following the graph lines, in connection with the showing of FIG. 23, these steps are computed mathematically, and the idealized fuel flow, temperature, and engine speed are determined from formulas. The resultant data is then compared with the actual measured data, and variances determined and stored.

In summary, therefore, the present comprehensive engine monitoring system not only provides detailed information relative to the nature of the exceedances, but also includes all data inputs required for, and the capability of trend monitoring, by calculating and plotting variations in fuel flow, temperature, and engine speed, as compared with the normalized ideal figures for a new turbine engine.

In conclusion, it is to be understood that the foregoing is a description of illustrative, preferred embodiments of the invention. Other electronic circuit arrangements for implementing the functions described hereinabove may be employed. By way of example, but not of limitation, other logic chips may be employed to implement the indicated function without departing from the spirit and scope of the invention; a series of thermocouples, resistance thermometers, optical temperature sensors, or any other means for measuring temperature, located at desired points along the turbine engine may be used instead of the schematic indication of a single thermocouple as shown in the drawing; and it is to be expected that the values as set forth in Table I and in FIG. 8 will vary from one turbine engine to another and that these are merely representative of particular engines under consideration. Also, differences in display and switching arrangements are expected between cockpit mounted and portable test units, and when one or three or four engine planes are involved, for example. It is also to be noted that all of the functions as described herein need not be included in every system; instead, it is to be expected that user requirements and needs will differ, and that most systems will use some but not all of the capabilities as disclosed hereinabove. Accordingly, the present invention is not limited to the particular systems as shown in the present drawings and as described in this specification.

What is claimed is:

1. A comprehensive aircraft turbine engine monitoring and recording system whereby said turbine engine has predetermined maximum normal operating parameters, said system comprising:

means for sensing the speed of rotation of said turbine engine; means for sensing temperature of said turbine engine; means for sensing altitude; means for determining exceedances indicating operation of said turbine engine over the normal operating temperature and/or speed of said engine; means for determining the air speed of said aircraft;

non-volatile storage means for permanently storing data giving the duration and magnitude of each said exceedance, and the total duration of the exceedances;

means for recording and processing data required for turbine engine trend monitoring, including means for calculating horsepower and the air density index factor, and the resultant optimum fuel flow rate, engine speed and engine temperature under these horsepower and air density conditions;

means for determining the actual fuel flow rate, engine speed and engine temperature;