1) Erroneous Reynold's Number

In the event that the flow is in the transition region, it is preferred that the first correction should be made for any known deviation in Reynold's number Rn from that which should apply. Then the correction for thermal conditions should be done. It may be necessary to iterate this process until it is deemed to have reached a limit. At that point, a determination of any remaining deviation of Rn should be made which could account for any remaining leak. If this assumption is deemed unreasonable, then the computed leak should be reported, but with a lower confidence factor than if the flow were in the turbulent region.

2) Aeration

Over some period of time it will be possible to correlate the reported effect of aeration detection value to the actual percentage of volume of liquid which it represents. When this level of confidence is reached, the lower level of confidence which must apply to any data reported under conditions of aeration may be increased somewhat. It may be necessary, for very high levels of aeration, to report a leak as being subject to severe skepticism.

3) Incorrect Thermal Parameters

Over a period of time it will be necessary to correct the initial thermal parameters to account for actual pipeline conditions. For example, if Kf is too high, then the actual pipeline temperature will be lower than that computed. If it is correct for some liquids, but not others, then it may be assumed that the viscosity component of that parameter is either too high or too low, dependent on which direction the error is found.

In addition, if the measured temperature is consistently more responsive to ambient temperature than the effect computed, it will be necessary to correct KPA. And if KPA appears to be correct for some range of pipe diameters, and not for others, then it may be necessary to correct the presently assumed inverse relationship. In addition, if there appears to be a lag in response to changes in ambient, it may be necessary to invoke a "thermal inertia" by adding "prior history" terms to the computation of section ambient temperatures from those measured at the site stations.

The system permits adjustment for actual measured temperatures, as may be found due to local geographic conditions, such as when passing through rivers, or over mountains.

4) Correction of Liquid Parameters

Since both the liquid viscosity and its coefficient of temperature expansion are factors in leak computation, it is essential that these parameters be as correct as possible. In cases where the only explanation for a verified error in leak computation is an error in the liquid parameters, the determination of what the particular parameters should have been is essential. In such cases, correction of data in the data bank should be made, with appropriate traceable notation.

In some cases, transient conditions, such as exist during interface passage, may make reporting of a leak, or masking of a leak, uncertain. It should be considered that if means is necessary to deal with liquid data parameter error under these conditions, then it should be given priority. However, if such conditions exist, then a lower confidence rating should be given to the current leak status report, even if it does not show a leak, but might be masking it.

A means of automatically analyzing data to determine the probable cause, or causes, of a lack of correlation between the computed temperature of the liquid at the second site station, TL2c, and the measured TL2, is also possible. This is because the "error" signal which results from the difference between this computed segment liquid exit temperature and the measured exit temperature permit a feedback correlation study of the known data reports for any given data integration period. Thus a "smart" or self learning system would result.

Development of an Artificial Intelligence AppCon Factor

It is known that pipeline conditions, and their effect on computed volume difference of flow in any pipeline segment, are subject to a wide variety of variations and combinatorial situations. As such there may be periods during which these conditions cause the appearance of a leak, rather than the actuality of there being a leak. The resultant false alarms must be avoided to prevent deterioration of the confidence of the operating staff in the system.

The system of the invention contains a means of conditioning the reported leak data with the operating staff's opinion as to the degree of validity of data during periods when operating conditions are less than ideal. This is done by an algorithm which produces a dimensionless number, based on the individual operating conditions which are included in the algorithm, which is multiplied with the "raw" difference data to produce the difference data used for alarm purposes. The number produced by this algorithm is called the application condition factor, or AppCon for short, and is a measure of the confidence that the system has in the leak data being accurate under the current operating conditions.

Now, the source factors which are included in the AppCon algorithm are:

Site Station Fault Alarm
Site Station Empty Alarm
Site Station Aeration condition
Flow Rate and Duration
Line Pack indication
Interface Passage indication
Thermal unbalance
Liquid condition

The AppCon algorithm includes assigned weighting factors for each of these items, and permits the operator to change these weighting factors so that the resultant AppCon factor suppress a false leak indication, if such has been detected and traced to a particular source factor. Thus, the operator has the opportunity to adjust these weighting factors to respond to the "personality" of the pipeline, and to his judgment of how the system should interpret data received during such periods of time.

Once expressed, the operator's judgment will be carried out automatically at all future times, applying the AppCon factor to adjust leak data in just the way he would have done personally if he were present at all times. Thus the occurrence of false alarms will be suppressed, and the confidence in the declaration of an actual alarm will be greatly respected.

Although the present invention has been described in relation to particular embodiments thereof, many other variations and modifications and other uses will become apparent to those skilled in the art. Therefore, the present invention should be limited not by the specific disclosure herein, but only by the appended claims.

What is claimed is:

1. A method of analyzing temperature data from a first and second predetermined position in a pipeline, the first and