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Application S/N 872,664
Filed: Oct. 30, 1969

Contractor: Caltech/JPL
Contract NAS7-100

69/201

AWARDS ABSTRACT

Inventor: Philip A. Jewell

October 7, 1969
NASA Case ~~No.~~ XNP-4162-2

DATA HANDLING SYSTEM BASED ON SOURCE SIGNIFICANCE, STORAGE AVAILABILITY AND DATA RECEIVED FROM THE SOURCE

The primary object of the invention is to provide a new data handling system for controlling the storage of data, received from various sources, in a buffer, as a function of various parameters.

The system (Figure 1) includes a first arrangement, shown comprising a counter 32, a D/A converter 34 and an analog function generator 36, which provides a first signal as a function of the available space in buffer 10. The buffer is used to store data, received from any one of sources S1, S2 and S3. When data is received from one of the sources, the output of the commutator 42, which represents a second arrangement, is a second signal, which is a function of the degree of significance of the source, supplying the data. A third arrangement, comprising counters 51-53, D/A converters 61-63 and commutator 48, provides a third signal which indicates the amount of data from the source, which supplies the data, which is already in the buffer 10, awaiting to be transmitted, or read out to a utilization unit. Only when the third signal is greater than the product of the first and second signals is data inhibited from being stored in the buffer.

The novelty of the system resides in the implementation of circuits to provide a particular data handling criterion. In accordance with this criterion the buffer accessibility for storing data is a function of not only the available space in the buffer, but also the significance of the source, providing the data, and the amount of data which was already received therefrom. Thus, under certain conditions, data may be stored in a buffer, which is nearly full, only if the data is received from a very significant source, or from a less significant source if very little data from the latter is in the buffer.

FIG. 2

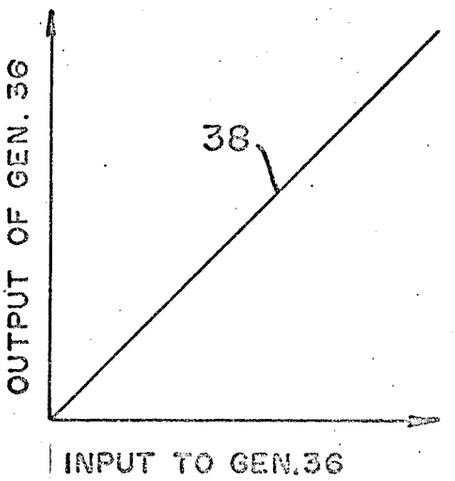
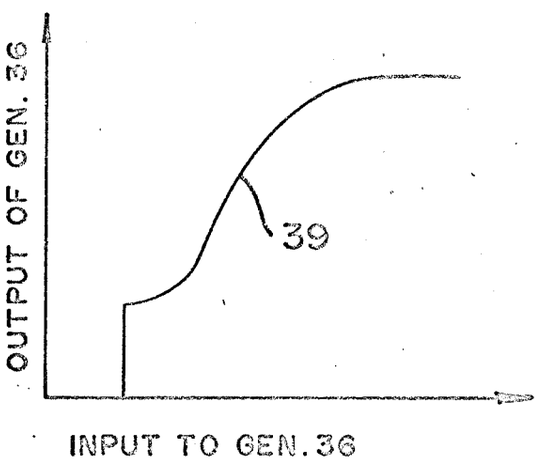


FIG. 3



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BY

ATTORNEYS

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~~69/201~~
NASA CASE XNP-4162-2

S P E C I F I C A T I O N

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT, PHILIP A. JEWELL, a British subject, citizen of the United Kingdom, residing at Cornerways, Prey Heath Close, Mayford, Woking, Surrey, England, has invented a new and useful

DATA HANDLING SYSTEM BASED ON
SOURCE SIGNIFICANCE, STORAGE AVAILABILITY
AND DATA RECEIVED FROM THE SOURCE

of which the following is a specification:

ABSTRACT OF THE DISCLOSURE

ORIGIN OF INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 USC 2457).

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation-in-part of Application Serial No. 448,899, filed April 16, 1965.

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention generally relates to data storage systems and, more particularly, to an improved data storage system in which data is handled as a function of data storage availability, the degree of significance of the data source, and the amount of data, already received therefrom.

2. Description of the Prior Art:

There are many cases in which data is received from a plurality of sources for ultimate use by a utilization unit. If the rate at which the data is

received from the various sources is greater than the rate at which data can be supplied to the utilization unit, a data storing device, generally referred to as a buffer, is employed. The buffer temporarily stores the data, received from the sources, until it can be supplied to the utilization unit. Since any buffer has a finite storage capacity, if the difference between the rate at which data can be supplied to the utilization unit and the rate or rates at which data may be received from the various sources is quite great, the buffer may overflow with data received from the sources, unless some special data handling technique is employed to prevent such overflow from occurring.

In cases in which the various sources, which supply the data, may be of different degrees of significance and may supply the data at different rates under different conditions, it is important that the employed data handling technique take into account these factors to insure that at any given time the space which is available in the buffer be available for storing data received from the more significant or important sources, or data from a less significant source from which very little data has been received. It had been discovered that a preferred data handling technique is one which controls the storage of data in the buffer as a function of the available buffer space, the degree of significance of the source which

is supplying the data, and the amount of data from the particular source which is already in the buffer, awaiting its use by the utilization unit. Such a technique has been found to be particularly useful in space exploration systems in which data, which may be received from a plurality of sources, such as sensors, is temporarily stored in a buffer for subsequent transmission to a ground receiver.

OBJECTS AND SUMMARY OF THE INVENTION

It is a primary object of the present invention to provide a new improved data handling system.

It is another object of the present invention to provide a new system for handling data, received from a plurality of sources, for temporary storage in a buffer.

It is a further object of the present invention to provide a new system for controlling the temporary storage of data, received from a plurality of sources, in a buffer for subsequent supply to a utilization unit, where the rate at which the data is supplied to the utilization unit is generally lower than the rate at which the data is received from the various sources.

These and other objects of the present invention are achieved by providing a data handling system which includes several arrangements for generating several different signals, each time data is received from any of the sources. These signals are combined in a unique novel manner to provide an indication whether the data from the source should be stored in the buffer, for subsequent supply to a utilization unit.

The data handling system includes one arrangement which provides a signal which is directly related to the availability of space in the buffer for storing data, which may be received from any of the sources. Thus, this signal may be thought of as the space-availability-indicating signal. The data handling system also includes a second arrangement which provides a signal, indicating the degree of significance of the source from which the data is received. The source's degree of significance is in relation to the degrees of significance of the other sources, from which data may be received. Such a signal may be thought of as representing a source-significance-indicating signal. A third arrangement, incorporated in the data handling system, provides a separate signal for each of the sources, indicating the amount of data from the particular source which is temporarily stored in the buffer and which awaits transmission or supply to the utilization unit. The later signal may be referred to as the stored-data-indicating signal.

In accordance with the teachings of the present invention, the three signals, generated in the system are utilized to determine whether data received from any of the sources should be stored in the buffer. As will be apparent from the following description, such a data handling system controls the storage of data in the buffer so that, under certain conditions which may exist, only data received from the more significant sources can be entered into the buffer while under other conditions, a significant amount of data received from the less significant sources may find access to the buffer for storage therein.

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a general block diagram of the present invention; and

Figures 2 and 3 are simple diagrams useful in explaining the operation of a function generator, shown in Figure 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference is now made to Figure 1 wherein block 10 designates a buffer to which data from a plurality of sources may be supplied for temporary storage and for subsequent supply or transmission to a utilization unit 15. For explanatory purposes, the number of sources is limited to three, the three being designated S1, S2 and S3. Data is assumed to be stored or written into buffer 10 through a buffer input unit 16, while data is read out from the buffer 10 into a buffer output unit 17 which is shown connected to the utilization unit 15. A Write/Read control unit 20 is connected to the buffer to control its Read or Write operations in manners, well known in the art.

In practice, an input unit 22, which may assume the form of a commutator, sequentially interrogates or senses the data lines from the various sources and sequentially loads the data, received therefrom into an input register 24. The data is entered into a data field of the register 24 while a number, identifying the source supplying the data, is entered into a source number field of register 24. The output of register 24 is directly connected to the buffer input unit 16. The data, loaded in the data field of the register 24, may be thought of as a multibit word, storable in a separate word location or cell in the buffer.

In accordance with the teachings of the present invention, the data received from any of the sources and which is loaded into the buffer input unit 16 is not stored or written into the buffer unless a Write signal is supplied to the control unit 20 by the data handling system of the present invention, designated in Figure 1 by numeral 30. Data is read out from the buffer 10 whenever a Read signal is supplied to unit 20 by the utilization unit 15. The buffer 10 may be assumed to be of the first in first out (FIFO) type.

Before proceeding to describe the data handling system 30 of the present invention in detail, it should be pointed out, that the input unit 22 interrogates the various sources at a rate independent of the rate of transmission of data from the buffer to the utilization unit 15. The rate of interrogation is made dependent on the maximum expected rate at which the various sources may be supplying meaningful data. It should further be pointed out, that the rate at which data is read out from the buffer 10 to the utilization 15 is independent of the rate at which data is supplied to the buffer 10. In practice however, it is assumed that the rate at which data is supplied to the buffer may be greater than the rate at which data is read out therefrom, so that the data handling system of the present invention is required to handle data so as to prevent the buffer 10 from overflowing.

As previously pointed out, the system of the present invention includes an arrangement which is designed to provide a space-availability-indicating signal. This arrangement may include an up/down counter 32 whose output is connected to a D/A converter 34. The two input terminals of such an up/down counter 32, which are generally designated as the Up and Down inputs are assumed to be connected to the Read and Write input lines of unit 20, respectively. The function of the counter 32 is to provide a running count of the available space in the buffer. The maximum count of the counter 32 may correspond to the maximum number of storage cells or locations in the buffer 10.

Assuming that initially the counter is set to its maximum count, each time data or a word is written into one of the buffer's cells, the count in the counter 32 is decremented by one, by supplying it with a Down input. On the other hand, each time data is readout from one of the cells, the count in the counter 32 is incremented by one by providing it with an Up input signal. Thus, at any given time, the count in the counter 32 represents the available cells in the buffer for data storage. Assuming for example a buffer with one thousand (1000) locations, an up/down counter with a maximum count of 1000 is used, so that when the buffer is empty, the count in counter 32 is a 1000, while being zero when the buffer is full.

As shown, the output of the counter 32 is supplied to the D/A converter 34 which converts the digital output of the counter and provides a related analog signal whose amplitude is analogous and directly related to the availability of the cells or storage space in the buffer for data storage. As shown, the output of the converter 34 is supplied to an analog function generator 36 whose output represents the space-availability-indicating signal.

Figures 2 and 3 to which reference is made herein are simple diagrams of two different functional relationships between the amplitudes of the input and output of the function generator 36. In Figure 2, the amplitude of output of the generator 36 is linearly and directly related to the amplitude of the input thereof as represented by the straight line 38. On the other hand in Figure 3 the amplitude of the output of the generator 36 is directly related to the amplitude of its input in other than a linear relationship, as represented by line 39. In either case, however, it is apparent that the amplitude of the output of the generator 36, which represents the space-availability-indicating signal is directly related to the availability of space in the buffer 10.

As previously pointed out, the data handling system 30 includes an arrangement which provides signals

as a function of the degrees of significance of the various sources, such as S1-S3. Such an arrangement may include a resistor 40, connected between a source of positive potential, such as +V and ground. Various taps of the resistor are connected to a commutator 42 whose output is connected to an analog multiplier 44. Each of the taps of resistor 40 is related to a different one of the sources.

Assuming that S1 is the most significant source, S2 the next most significant source and S3 the least significant source, the tap connected to the top of the resistor at potential +V may be assumed to be associated with the most significant source S1, while the tap connected at a potential +V/2 is assumed to be associated with S2 and the tap at a point in the resistor 40 where the potential is +V/4 is assumed to be associated with the source S3. The commutator 42 operates in synchronization with the input unit 22. Consequently, the potential of the output of commutator 42 which is supplied to the analog multiplier 44, and which represents the source-significance-indicating signal depends on the particular source, whose data the input unit 22 transfers to the input register 24. Assuming that data from source S2 is commutated through input unit 22 to register 24, the potential supplied by commutator 42 to the analog multiplier 44 is +V/2.

As shown in Figure 1, the outputs of the analog function generator 36 and the commutator 42, which represents the space-availability-indicating signal and the source-significance-indicating signal, respectively, are multiplied by the analog multiplier 44, whose output, representing a product signal, is supplied to one input of an analog comparator 46. The other input of comparator 46 is supplied from a commutator 48, which operates in synchronism with the input unit 22 and commutator 42.

Basically, the output of commutator 48 represents the stored-data-indicating signal. As shown in Figure 1, for the three source arrangement, the data handling system 30 may include three up/down counters designated 51, 52 and 53, whose outputs are respectively supplied to D/A converters 61, 62 and 63. The outputs of the latter-mentioned D/A converters are supplied to the commutator 48 which operates in synchronism with input unit 22 and commutator 42.

The function of each of counters 51-53 is to store a count, which represents the amount of data which is in the buffer 10 which was received from the source with which the counter is associated and which awaits communication to the utilization unit 15. Assuming counters 51-53 are associated with sources S1-S3, the count in counter 51 represents the amount

of data in the buffer which was received from S1 and which awaits to be supplied to unit 15. Similarly, the counts in counters 52 and 53 represent the amounts of data, or the number of words of data, from sources S2 and S3 respectively, which are in the buffer. Each D/A converter, such as 61, merely converts the count in its associated counter into an analog signal. Thus, the amplitudes of the outputs of converters 61-63 represent, in analog form, the amounts of data or words in buffer 10 from S1-S3 respectively, which await to be transmitted to unit 15.

The count in each of counters 51-53 is incremented by one when data from its associated source is stored or written into the buffer, while it is decremented by one when data or a word in buffer 10, which was received from its associated source, is read out and transmitted to the utilization unit 15. As shown, the system 30 includes source-number decoders 71 and 72. Whenever a determination is made to store data received from one of the sources in the buffer, the decoder 71 is enabled. It decodes the number of the source supplying the data and increments its counter. The enabling of the decoder may be achieved by the output of the analog comparator 46 which represents the Write signal.

Thus, for example, if the data in the register 24 is from source S2 and a determination is made to store or write the data into the buffer 10, the source number decoder 71 increments the count in counter 52, associated with S2, thereby indicating an increase in the amount of data from S2 in the buffer 10. Likewise, the source number decoder 72 responds to the source number in the buffer output unit 17. Consequently, each time data is read out from the buffer 10, for supply to the utilization unit 15, the source number is decoded and the counter, associated with the particular source whose data has just been read out from the buffer 10, is decremented by one to indicate a decrease in the amount of data from the particular source in the buffer 10.

In accordance with the teachings of the present invention, the analog comparator 46 provides a Write signal to the Write/Read control unit 20 to enable the writing or storing of the data, which is in the buffer input unit 16, only when the amplitude of the product signal, representing the output of the analog multiplier 44 is equal to or exceeds the amplitude of the stored-data-indicating signal, supplied by the commutator 48. That is, in accordance with the teachings of the present invention the buffer is made accessible to store data from a particular source only if the product of the space-availability-indicating signal and the source-significance-indicating signal is equal to or greater

than the stored-data-indicating signal, the latter representing the amount of data from the particular source which is already in the buffer 10, awaiting transmission to the utilization unit 15. Thus, the storing of data in the buffer is a function of the availability of space in the buffer, the degree of significance of the source supplying the data, in relation to the degrees of significance of the other sources, and the amount of data from the particular source which is already in the buffer.

Clearly, if the buffer is nearly empty, the amplitude of the space-availability-indicating signal is quite high so that the amplitude of the product signal is quite high even though the degree of significance of the source may be low. Consequently, unless a very large amount of data from the particular source is already in the buffer, awaiting transmission, the buffer will be accessible to store the data received from the relatively insignificant source. On the other hand, if the buffer is nearly full, the amplitude of the space-availability-indicating signal is very low and consequently, the amplitude of the product signal is very low. As a result, the buffer is not accessible to any of the less significant sources, unless the stored-data-indicating signal related thereto is very low, which is the case only if very little data from the particular source is in the buffer 10, awaiting transmission to the utilization unit 15.

The significant advantages realizable with the data handling system of the present system may best be highlighted in conjunction with a specific example. Let it be assumed that data is received from source S2 and a determination has to be made whether the data should be stored in the buffer 10. In such a case, the commutator 42 supplies the analog multiplier 44 with a source-significance-indicating signal of a potential which is equal to +V/2. This is true since S2 is assumed to be the middle source in terms of degree of significance and, therefore, its significance is indicated by the potential at the center tab of resistor 40.

The decision to store or write the data from S2 in the buffer 10 depends on the amplitude of the product signal as compared with the amplitude of the stored-data-indicating signal, supplied by commutator 48, which in the particular example represents the analog output of D/A converter 62. If the buffer is relatively empty, and very little data from S2 is in buffer 10, the product signal may be greater than the analog output of D/A converter 62. Consequently, a Write signal will be supplied by the analog comparator 46 to the Write/Read control unit 20 to cause the storing of the data, received from S2, in the buffer.

On the other hand, if the buffer is relatively full, so that the amplitude of the product signal is

less than the stored-data-indicating signal, or if the amount of data from S2 in the buffer, which is awaiting transmission to the utilization unit 15, is very high, the stored-data-indicating signal may be greater than the product signal, supplied to the analog comparator 46. In such a case, a Write signal would not be supplied by the analog comparator 46. Consequently, the data from S2 will not be stored in the buffer 10.

It should be appreciated that under the same conditions of space availability in the buffer and assuming the same amount of data in the buffer 10 from S1 and S2, while the data from S2 may be inhibited from being stored in the buffer, data received from S1 may be storable therein. This may happen since the output of commutator 42 is the highest, when data is received from S1, assumed to be the most significant source. Consequently, the product signal from multiplier 44 may equal or exceed the signal from D/A converter 61 to result in a Write signal from comparator 46 for the storing of data from S1. Thus, it should be appreciated that when the same amount of data from different sources is in the buffer 10, the latter may be accessible to store data from the more significant sources, while being unavailable for storing data from less significant sources.

The teachings of the present invention may be incorporated in a communication system in which the utilization unit 15 is a transmitter which receives data from the buffer for transmission to a receiver. For example, the invention may be incorporated in a space exploration communication system to compress data, produced by a plurality of sources, such as sensors, before it is supplied to a transmitter, such as unit 15, for transmission to a ground receiver.

It should be pointed out that each source S may be producing data at a different rate. Thus, in order to minimize loss of data it may be desirable for the input unit 22 to interrogate or sense the various data lines from the various sources at a sufficiently high rate, so that all the data from each source may be stored in the buffer, if the particular data handling criteria, herebefore explained are met. Clearly, the input unit 22 may include several different commutators to interrogate different sources at different rates, and the outputs of these commutators may then be combined to sequentially supply data from the various sources to the register 24 and unit 16. Then, as each data or word is received the data handling system 30 may determine whether the data should, or should not, be stored in the buffer 10. Since the invention is not directed to commutating techniques, to receive data from different sources, which are well known in the art, the input unit 22 will not be described in any further detail.

From the foregoing it should thus be apparent that in accordance with the teachings of the present invention the storage of data, received from any one of a plurality of sources, in a finite storage capacity buffer depends on several factors. It depends on the availability of storage space in the buffer, the significance of the source, supplying the data, and the amount of data from the source which is already in the buffer, awaiting to be supplied or transmitted to a utilization unit. Such a system enables data from any source to be stored in the buffer when the latter is nearly empty, while reserving available buffer space for data from the more significant sources as the buffer fills up. It should however be pointed out that even when the buffer is nearly full, data from a source of low significance may be stored in the buffer if very little data, if any, from such a source is in the buffer. This capability is realized by the present invention since the storing of data, in accordance with the teachings disclosed herein, is a function not only of the available buffer storage space and source significance, but also of the amount of data from each source in the buffer.

Although a particular embodiment of the invention has been described and illustrated herein, the embodiment and the data handling criteria, employed therein, have been presented to explain the invention

rather than to limit its scope. It is recognized that modifications and variations may readily occur to those skilled in the art.

For example, although the invention has been described in connection with an analog embodiment, it should be apparent that the teachings are equally implementable with digital circuits. Thus, the analog embodiment should be regarded as an example used to describe the invention rather than to limit it. Also herebefore the source-significance-indicating signals, provided by the potential across resistor 40 represent hardwired or fixed signals. Clearly, if desired the invention may include means which could dynamically change the relative degrees of significance of the various source, during the system's performance. This is particularly advantageous if during actual operation an otherwise insignificant source becomes very important. The system may further be modified so that the utilization unit 15 produces the Read signal only when a word is read out from the buffer and unit 15 decides not to retain the word in the buffer. This is analogous to a "dump" operation. If however the unit 15 decides to retain the word in the buffer, the Read signal is not produced.

Herebefore the invention has been described mostly in the context of a communication or transmission system. However, it is not intended to be limited thereto.

The novel invention may find application in any system in which data which is or may be received from a plurality of sources requires special handling. For example, it may be employed in a time-sharing computer system in which requests for computer operations are received from several computer users or terminals and the computer system must define an order in which these requests are to be performed. Likewise, the invention may be incorporated in a banking computing system in which the total storage capacity of the buffer 10 may be analogized to the total bank capital and the sources to bank customers to when bank capital is made available as a function of their importance (significance), available capital and the amount of capital these customers have already received.

CLAIMS

WHAT IS CLAIMED IS:

1. In a system of the type wherein data produced by a plurality of sources is received for temporary storage in a data storage buffer of finite storage capacity for subsequent supply to a utilization unit, a data handling system for controlling the data received from said sources, which is stored in said buffer, the data handling system comprising:

analysis means for selecting data, received from each of said sources, for storage in said buffer as a function of the availability of storage space in said buffer, the relative significance of the source from which the data is received as compared with the degrees of significance of the other sources and the amount of data from said source which is in said buffer.

2. A system as recited in Claim 1 wherein said analysis means include first means for providing a first signal indicative of the availability of storage space in said buffer, second means for providing a second signal indicative of the significance of the particular source, providing the data, with respect to the other sources, third means for providing a third signal indicative of the amount of data from the particular source in said buffer, and means for controlling the storing of the data from said particular source in said buffer as a function of the relationship between said first, second and third signals.

3. In a data communication system of the type including means for receiving data from any one of a plurality of sources, a buffer of a predetermined maximum storage capacity for temporarily storing data from the sources and means for transmitting data stored in said buffer to a receiver, the improvement comprising:

first means for providing a first signal indicative of the available storage capacity of said buffer;

second means for providing a second signal representing the degree of significance of any one source as compared with the other sources;

third means for providing a third signal indicative of the amount of data of said one source already stored in said buffer; and

control means for controlling the storage of data from said one source in said buffer as a function of said first, second and third signals.

4. The improvement as recited in Claim 3 wherein said control means includes multiplying means for providing a fourth signal which is the product of said first and second signals, and comparing means for comparing said third and fourth signals to control the storing of data as a function of the comparison therebetween.

5. The improvement as recited in Claim 4 wherein said comparing means provides a storing control signal only when said third signal is not greater than said fourth signal.

6. A data handling system comprising:

first means for receiving data from any one of a plurality of sources;

buffer means having a finite data storing capacity, said buffer means including a plurality of cells each adapted to store data supplied thereto;

data utilization means coupled to said buffer means and adapted to supply a Read signal thereto to cause said buffer means to read out from said data utilization means data stored in one of its cells; and

data handling means coupled to said buffer means for controlling the storing of data, received from any of one of said sources, in said buffer to be a function of the available cells in said buffer means for storing data, the degree of significance of the source from which data is received and the amount of data from said source supplied to said data utilization means.

7. The arrangement as described in Claim 6 wherein said data handling means include a first counter for providing a count representing the number of cells in such buffer means which are available for storing data, and a separate counter for each source, the count in said separate counter indicating the amount of data from the source which is in said buffer means awaiting to be supplied to said data utilization means.

8. The arrangement as described in Claim 7 wherein said data handling means include means for providing a signal whose amplitude is directly related in other than a linear relationship to the number of available cells in said buffer means for storing data therein.

9. The method of handling data, received from a plurality of sources, for storage in a buffer from which data is read out at a rate independent of the rate at which data is received, the steps comprising:

generating a first signal which is a function of the availability of space in the buffer for storing data therein;

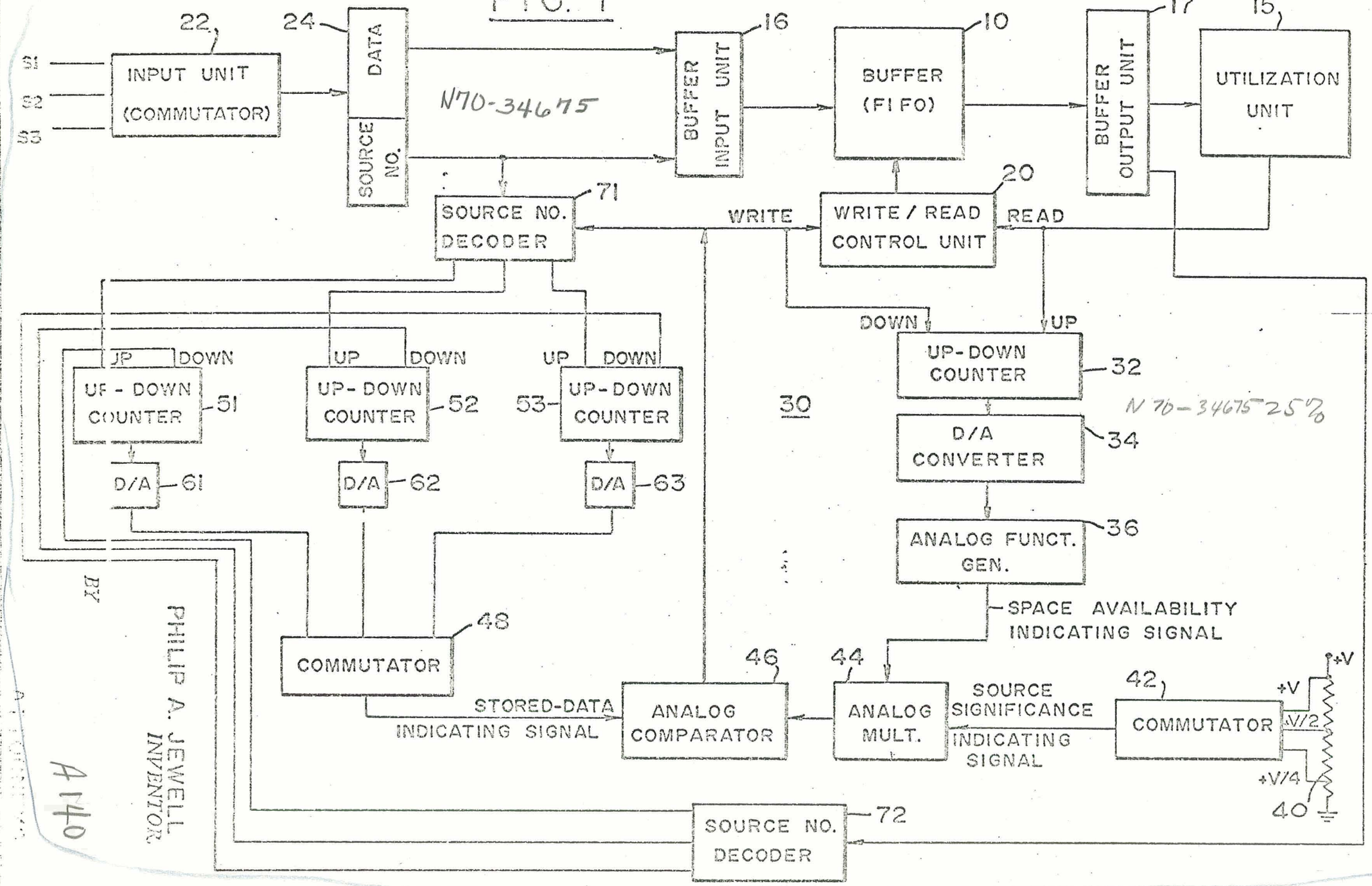
generating a second signal, when data is received from one of said sources, which is a function of the relative degree of significance of said one of said sources;

generating a third signal, when data is received from said one of said sources, which is a function of the amount of data from said one of said sources which is in said buffer; and

controlling the storing of data from said one of said sources in said buffer as a function of the relationship between said first and second signals and said third signal.

10. The method as recited in Claim 9 wherein said controlling step includes the steps of multiplying said first and second signals to provide a product signal, comparing said product signal with said third signal, and storing said data only when said product signal is not less than said third signal.

FIG. 1



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