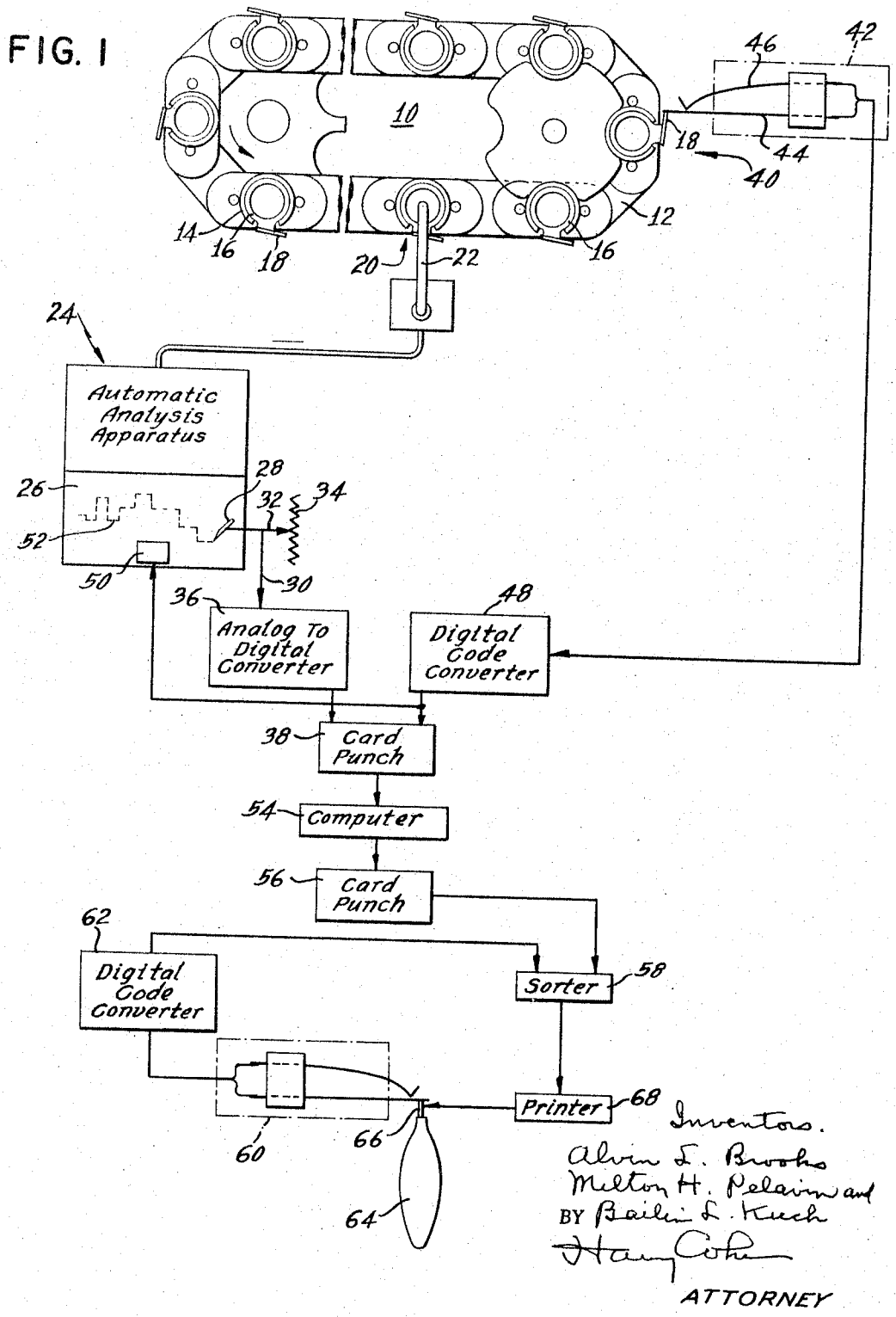
May 16, 1967 B. L. KUCH ETAL 3,320,618

SAMPLE ANALYSIS APPARATUS

Filed Nov. 27, 1964

3 Sheets-Sheet 1

FIG. 1



Inventors.
Alvin L. Brooks
Milton H. Pelavin and
BY Bailin L. Kuch
Harry Cohen
ATTORNEY

May 16, 1967 B. L. KUCH ETAL 3,320,618

SAMPLE ANALYSIS APPARATUS

Filed Nov. 27, 1964 3 Sheets-Sheet 2

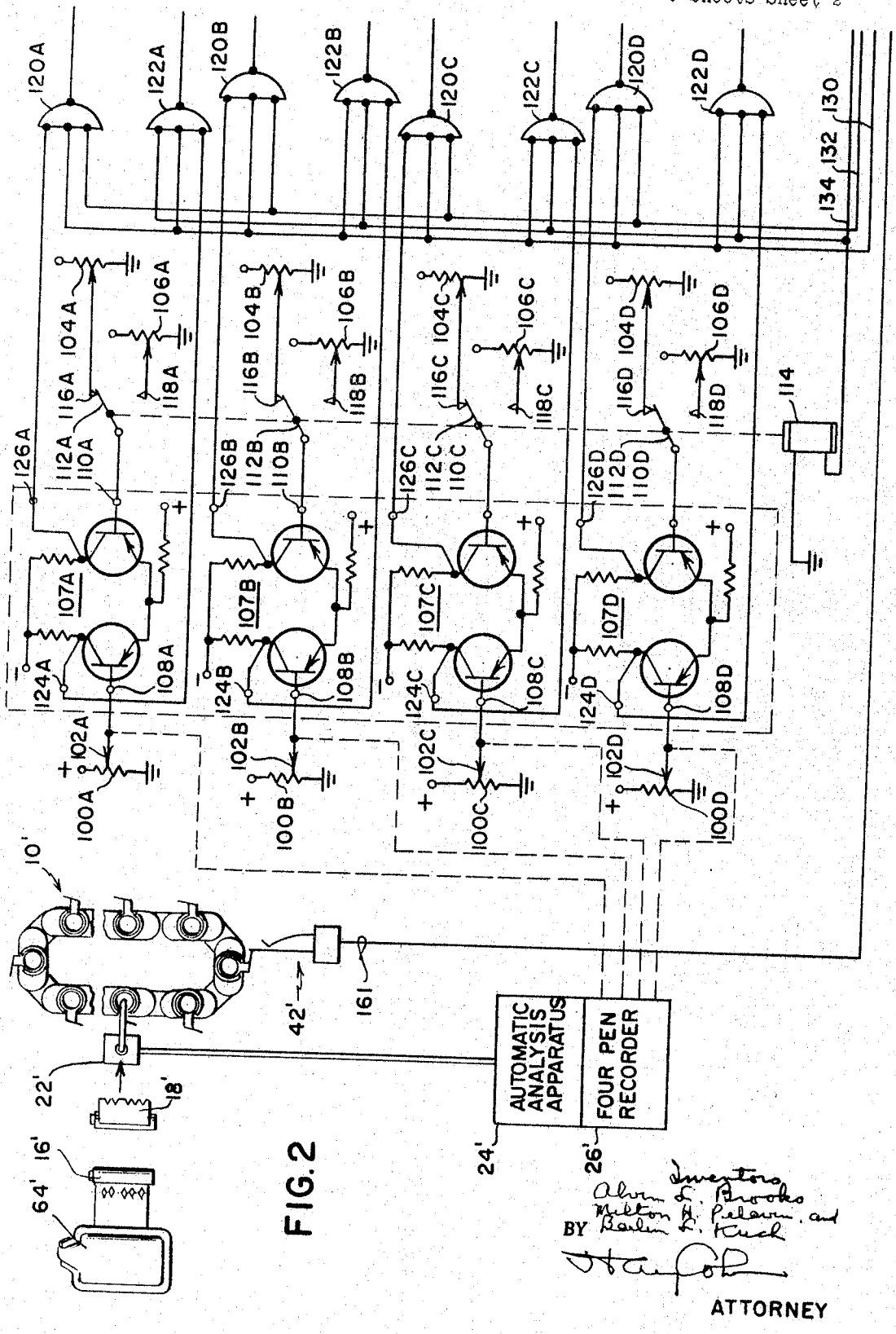


FIG. 2

Inventors
Alvin L. Brooks
Milton H. Pelavin and
Berlin L. Kuch
BY
ATTORNEY

May 16, 1967 B. L. KUCH ETAL 3,320,618

SAMPLE ANALYSIS APPARATUS

Filed Nov. 27, 1964

3 Sheets-Sheet 3

FIG.3

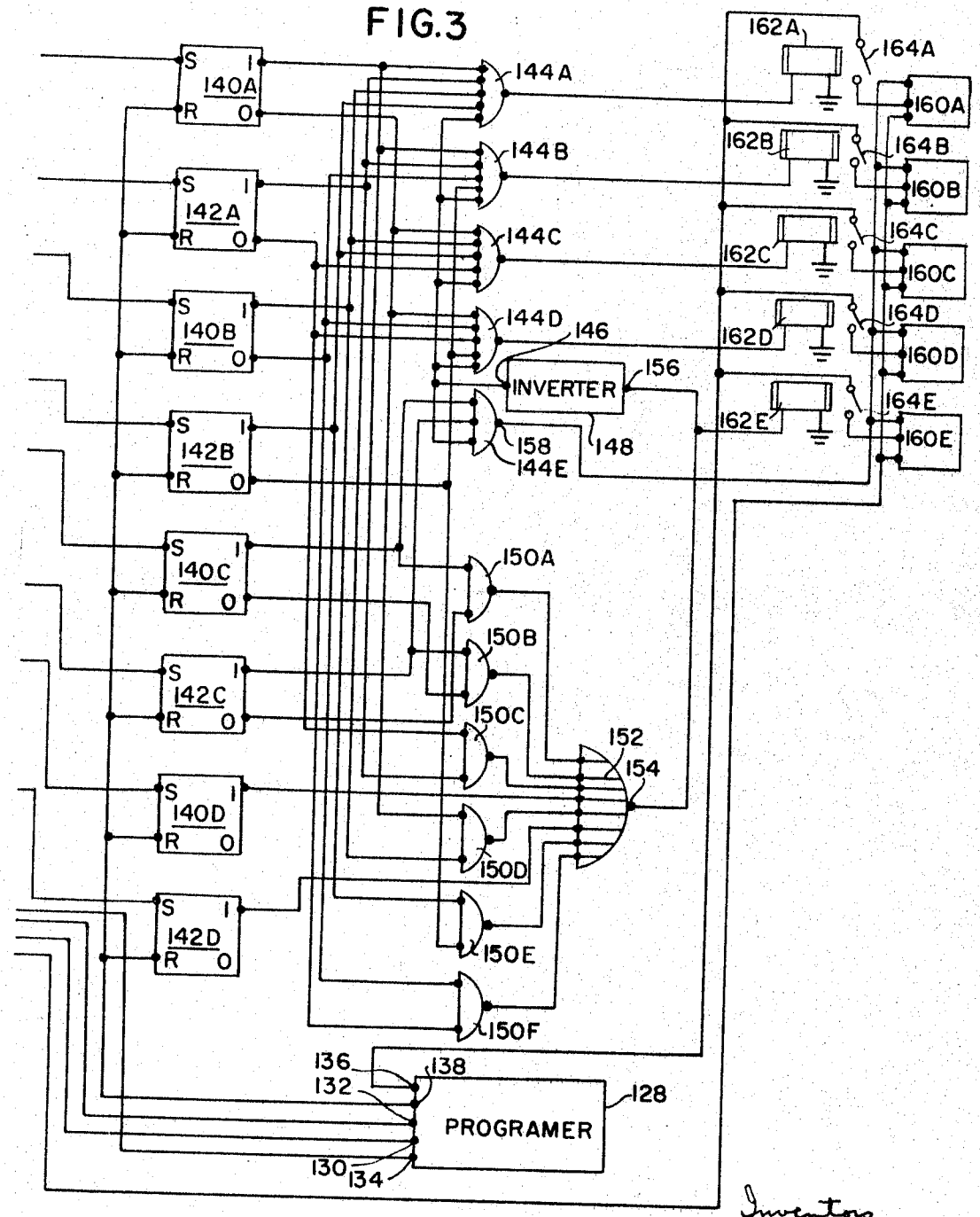
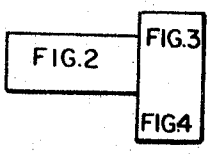


FIG.4



Inventors
Alvin L. Brooks
Milton H. Palavin
Bailin L. Kuch
BY Harry Cohn
ATTORNEY

United States Patent Office 3,320,618 Patented May 16, 1967

3,320,618

SAMPLE ANALYSIS APPARATUS

Bailin L. Kuch, Brooklyn, Milton H. Pelavin, Greenburgh, and Alvin L. Brooks, New City, N.Y., assignors to Technicon Instruments Corporation, Chauncey, N.Y., a corporation of New York

Filed Nov. 27, 1964, Ser. No. 414,302
16 Claims. (Cl. 346—35)

This invention relates to the automatic identification of substances, and more particularly to the automatic identification, analysis and documentation of substances.

A major problem in many analytic procedures involves insuring that the results of an analysis of a sample are positively correlated with the sample which was analyzed. A further problem involves insuring that the sample which was analyzed (and the results of the analysis) are positively correlated with the supply from which the sample was taken. A prime example of these problems is found in the operation of a blood bank. Customarily, a supply of blood is drawn from a donor. A sample of the drawn blood is analyzed, inter alia, for blood type. The blood type is correlated to the supply of drawn blood. The supply of typed blood is given to a patient requiring blood of that particular type. The customary system is fraught with potential clerical errors. Initially, the blood is drawn separately into an independent sample storage container. Identification numbers are manually placed on these containers. The samples are each analyzed and the blood type thereof determined. The blood type is manually recorded in correlation with the identification number. When blood of a particular type is required, the identification number of a storage container having that type of blood is manually obtained, and the corresponding storage container is manually selected. If blood of an incorrect type is given to a patient, the result may be fatal.

In the U.S. patent application of Jack Isreeli, S.N. 391,093, filed Aug. 21, 1964, and assigned to the assignee of this application, there is shown, inter alia, a main storage container for a supply of blood, a sample storage container for a sample of the blood in the main container, and an indicia carrier attached to and between the two containers. The indicia carrier is initially provided with a row of holes along a line of severance in a combinational array which uniquely identifies the assembly. After blood from the same donor has been stored in both containers, the indicia carrier is severed, resulting in each container having a portion of the carrier attached thereto which has an edge provided with a row of notches in a combinational array which is identic with the original row of holes. The sample container may then be placed on an automatic sampler of an automatic analysis system with other containers. Each container is serially passed to a first station at which blood is removed from the container, analyzed and the analysis results charted on a recorder; and subsequently passed to a second station at which the indicia associated with the container are automatically sensed and the identification number printed adjacent the charted analysis results on the recorder.

It is an object of this invention to provide a system wherein both the results of the analysis of a sample and the identification number of that sample are digitally recorded in correlation.

It is another object of this invention to provide a system wherein both the results of the chemical analysis of a sample and the identification number of that sample are automatically digitally recorded on a document which may be automatically processed by a computer to analyze the chemical analysis results, as for example to determine

the blood type, and to record this determination in conjunction with the identification number.

It is still another object of this invention to provide a system wherein the main storage container may be automatically identified, and the predetermined blood type or other results of the chemical analysis may be automatically obtained and printed on the main storage container.

A feature of this invention is the provision of means for automatically extracting a sample from a sample container, chemically analyzing the sample, and providing the results in digital form; means for automatically sensing the identifying indicia on the sample container and providing the identification number in digital form; and means for automatically recording the results in correlation on a document which may be processed by a computer.

These and other objects, features and advantages will become apparent by reference to the following description of the invention considered in conjunction with the accompanying drawings in which:

FIGURE 1 is a diagrammatic view of a system embodying this invention; and

FIGURE 2 and 3 are a diagrammatic view of a second system embodying this invention when taken together as indicated in FIGURE 4.

In the drawing, the container assemblies have been prepunched, filled with blood, severed and the sample containers placed in a sampler **10** as shown in the Isreeli application, supra. The sampler includes an endless sprocket chain **12** to which are mounted vertical, tubular, sample container carriers **14**. A tubular sample container **16** is disposed in each carrier **14** and has a notched edge card **18** attached thereto by a boss which projects through a vertical slot in the carrier. The chain intermittently conveys each of the containers to a first station **20** at which a sample off-take tube **22** is located. A suitable sample tube which is translated in a given plane is shown in the United States patent to Jack Isreeli and Theodore Bilichniansky, U.S. 3,251,229, issued May 17, 1966.

In the first embodiment of FIGURE 1, the off-taken samples are supplied as a continuous stream to an automatic analysis apparatus **24** having a recorder **26**. A suitable automatic analysis apparatus is shown in the U.S. patent to Leonard T. Skeggs, Edwin C. Whitehead, William J. Smythe, Jack Isreeli and Milton H. Pelavin, U.S. 3,241,432, issued March 22, 1966. The reaction part of the apparatus may be set up for blood typing according to the U.S. patent application of William J. Smythe, S.N. 221,570, filed Sept. 5, 1962, and assigned to the assignee of this application. The recorder **26** of the Skeggs et al. application, supra, includes a potentiometer slide wire coupled pen **28** which charts a constant value for each of the analyses performed on each sample. The return conductor **30**, which is coupled to the sliding contact **32** of the potentiometer **34**, is thus energized with a voltage which is a function of the result of the analysis. This conductor **30** is coupled to the input of an analog to digital converter **36**. Alternatively, should a recorder be utilized which itself does not provide a constant analog output signal for each of the analyses performed on each sample, then a suitable peak detection and holding circuit, for example and not by way of limitation, such as is shown in the U.S. patent to Milton H. Pelavin, U.S. 3,167,377, issued Jan. 26, 1965, may be coupled between the return conductor **30** and the converter **36**. The output of the converter **36** is coupled to the input terminals of a card punch **38**. The converter **36** provides a parallel digital output for actuating the punch elements to punch a digital value in a document, such as a punch card, which value is representative of the voltage on the con-

ductor **30**. The card punch **38** thus punches in the card one or more sets of digits which are representative of the results of one or more analyses performed on the specific sample. The card punch automatically indexes the card so that several numbers may be punched therein.

The operation of the chemical analysis apparatus requires a finite time from start to finish, and the off-taken sample container is advanced from the first station **20** towards a second station **40**. When the analysis is almost completed the off-taken sample container is halted at the second station. A read-out mechanism **42**, such as is disclosed in the Isreeli application, supra, having a plurality of spaced apart parallel wires **44**, is disposed at the second station. The wires engage the notched edge of the card **18**. Those wires which are adjacent notches on the edge of the card **18** pass into these notches. Those wires which are adjacent lands on the edge of the card are deflected into contact with a ground bus **46**. A potential is applied to the wires, and continuity to ground is established in each deflected wire. The output signals from the read-out mechanism are coupled to the input terminal of a digital code converter **48** which converts the code utilized on the edge notched card **18** to the code utilized by the card punch **38**. This may involve a conversion from a two out of five code to a decimal code. The output signals from the code converter **48** are coupled to the input of the card punch **38**. The card punch punches the identification number of the sample into the same card in which the results of the analyses of that particular sample are punched.

The output signals of the code converter **48** are also coupled to the input terminals of a digital printing mechanism **50**, as shown in the Isreeli application, supra. The printing mechanism prints the identification number of the particular sample adjacent the curves **52** representing the analytic results of that particular sample. These curves may be manually interpreted if necessary to provide the results of the analysis and to serve as an independent record of the analysis of each sample.

The determination of the blood type of a sample of blood, or any similar multiple analysis, requires the measurement of the intensity of each reaction, and the logical interpretation of these measurements. The measurement is provided by the analytic system **24**. The logical interpretation is readily performed by a suitably programmed computer. For example, consider the ABO blood group system: The red cells in type A blood have type A antigens and are agglutinated by serum having type Anti-A antibodies. The red cells in type B blood have type B antigens and are agglutinated by serum having type Anti-B antibodies. The red cells in type O blood are not agglutinated by either a serum having type Anti-A antibodies or a serum having type Anti-B antibodies. The red cells in type AB blood have both types A and type B antigens and are agglutinated by either a serum having type Anti-A antibodies or a serum having type Anti-B antibodies. A portion of the unknown blood sample is reacted with Anti-A serum, and another portion is reacted with Anti-B serum. The blood type determination of the agglutination results requires a simple logic circuit: not A·B=type B; A·not B=type A; not A·not B=type O; A·B=type AB. A more detailed discussion of the practice of blood typing may be found in the Medical Research Council Memorandum No. 36, "The Determination of the ABO and Rh(D) Blood Groups for Transfusion," Her Majesty's Stationery Office, London, 1958.

The cards punched by the card punch **38**, bearing the sample identification number and the raw results of the multiple analyses for that sample, are fed into a computer **54** which determines the blood type and punches this determination by means of an output card punch **56** on either a new card together with the sample identification number, or on the original card previously punched with the results of the analyses.

These blood type cards provided by the card punch **56** are now fed into a sorter **58**. The sorter is controlled by a read-out mechanism **60** similar to the read-out mechanism **42** whose output signals are coupled to the input terminals of a digital code converter **62** which is similar to the converter **48** and whose output signals are coupled to the input terminals of the sorter. Each of the main blood containers **64** is brought to the read-out mechanism **60** and its notched edge card **66** is sensed to determine its identification number. The sorter **58** sorts the card until it finds the blood type card having the identification number sensed by the read-out mechanism **60**. The sorter reads out the blood type from this card and these output signals are coupled to the input terminals of a printer **68** which prints the blood type on the notched edge card **66** of the main blood supply container **64**. The printer may also print out on the card **66** the identification number to show that the sorter **58** did locate the correct card.

Thus each blood sample has been automatically off-taken, analyzed, identified, determined, and the determination printed on the associated main blood supply.

Although an embodiment has been disclosed utilizing a sample liquid, sample solids may also be processed according to this invention. In such a case, the solid to liquid converter apparatus, shown in the United States patent application of Andres Ferrari and Nelson G. Kling, S.N. 222,013, filed Sept. 7, 1962, now Patent No. 3,223,485, and assigned to the same assignee as this application, may be incorporated into the sampler apparatus.

Further, although a card system has been shown as a buffer storage for the computer, other storage media may be utilized, such as punched tape, or magnetic tape, wherein the identification number of the sample and the results of the analyses on that sample are correlated, or the information may be sent to the computer directly without buffering. Similarly, although a card system has been shown as an output storage for the computer, other media, such as punched tape or magnetic tape, may be used, so long as the identification numbers and results are correlated and may be sorted.

Finally, if a logical analysis of the chemical analysis is not required, then the computer and its buffer storage may be omitted, with the output from the sample container reader and the automatic analysis apparatus being stored directly in the sorter storage.

In the second embodiment, shown in FIG. 2, the sample container **16'** containing a blood sample is detached from its supply container **64'**, retaining its notched edge card **18'**. The sample container **16'** is centrifuged to separate the drawn blood into two portions, viz.: an upper plasma portion and a lower red cell portion. The container **16'** is then placed in a sampler **10'** having an off-take mechanism **22'** disposed at a first station and a readout mechanism **42'** disposed at a second station. The off-take mechanism includes two off-take tubes, one long tube which aspirates the red cells from the lower portion of the container, and one short tube which aspirates the plasma from the upper portion of the container. Such an off-take mechanism is shown in the U.S. patent to Nelson G. Kling, U.S. 3,252,330, issued May 24, 1966. The off-take mechanism is coupled to an automatic analyzer apparatus **24'**, such as is shown in the U.S. patent application of Jack Isreeli and Milton H. Pelavin, S.N. 316,264, filed Oct. 15, 1963, and assigned to the assignee of this application. In this analyzer apparatus each sample of red cells is divided into four portions, and the companion sample of plasma is also divided into four portions, and these eight samples are processed contemporaneously. As shown in the U.S. patent application of William J. Smythe, S.N. 221,570, filed Sept. 5, 1963 and Vox Sanguinis, vol. 8, pp. 438–451 (1963), the first portion of red cells is reacted with Anti-A serum, the second portion of red cells is reacted with Anti-B serum, the third portion is reacted with Anti-D or Rh serum, and the

fourth portion of red cells is mixed with a saline solution as a control. Further, the first portion of plasma is reacted with type A cells, the second portion is reacted with type B cells, the third portion is reacted with type O cells, and the fourth portion is mixed with a saline solution. The lengths of the reaction channels differ slightly so that the reacted red cell sample portions arrive concurrently in their respective four flow cells ahead of the concurrent arrival of the companion reacted plasma sample portions in their respective four flow cells. The analyzer concurrently measures the optical density of the red cell portions in their respective flow cells and the four pen recorder **26'** concurrently records these values; then the analyzer concurrently measures the optical density of the plasma portion in their respective flow cells and the recorder concurrently records these values.

Each of the channels of the four pen recorder has a respective potentiometer resistance **100A**, **100B**, **100C**, **100D** and a sliding tap **102A**, **102B**, **102C**, **102D** therefor on which a potential is developed which is responsive to the optical density of the liquid in the respective flow cell.

The antigen and antibody content of the several blood types is set out in Table I, while the agglutination reaction of the red blood cells and the sera are set out in Tables II and III.

If there is an agglutination reaction for a sample, the agglutinated red cells, either from the sample cells, or from the test cells in the case of sample sera, will be removed from the channel, as shown in S.N. 221,570, supra, and after the sample is treated to lyse any red cells therein for color will have a low optical density (high light transmittance) since there will have been very few red cells left in the sample to provide color. Thus the agglutination reactions for sample cells and sample sera of the same type will be opposite in result. There will be no agglutination reaction when a saline solution is added in lieu of a blood reagent.

TABLE I

[The antigens and antibodies in blood of different groups]

Blood group	Antigens on red cells	Antibodies in serum
O	Neither A nor B	Anti-A and Anti-B.
A	A	Anti-B.
B	B	Anti-A.
AB	A and B	Neither.
Rh positive	D	None.
Rh negative	None	Anti-D.

TABLE II

[Reactions of cells of different groups with sera]

Blood group	Reaction with Anti-A serum	Reaction with Anti-B serum	Reaction with Anti-D serum
O	No agglut	No agglut	
A	Agglut	No agglut	
B	No agglut	Agglut	
AB	Agglut	Agglut	
Rh positive			Agglut.
Rh negative			No agglut.

TABLE III

[Reaction of sera from blood of different groups with cells of groups A and B]

Blood group	Reaction with A cells	Reaction with B cells
O	Agglut	Agglut.
A	No agglut	Agglut.
B	Agglut	No agglut.
AB	No agglut	No agglut.

The test criterion is whether the optical density of a sample portion exceeds or does not exceed a predetermined value. This threshold for each of the eight portions of the total blood sample is established by a respective potentiometer. Potentiometers **104A**, **104B**, **104C** and **104D** provide the red cell thresholds, while potentiometers **106A**, **106B**, **106C** and **106D** provide the plasma thresholds. The potential at the recorder potentiometer is compared with the respective threshold potential in that channel by one of four comparators **107A**, **107B**, **107C**, **107D**, each having a respective sample input terminal **108A** through D, and a respective threshold input terminal **110A** through D. Each of the comparators is constructed as a differential amplifier.

The inputs **110A–D** are normally coupled to the red blood cell threshold potentiometers **104A–D** through the moving contacts **112A–D** of a relay solenoid **114** and the fixed contacts **116A–D** respectively. When the relay solenoid **114** is energized, the inputs **110A–D** are coupled to the plasma threshold potentiometers **106A–D** through the moving contacts **112A–D** and the fixed contacts **118A–D**. Associated with the four comparators are four cell output AND gates **120A–D**, and four plasma output AND gates **122A–D**. Each comparator has an output terminal **124A–D** which will provide a significant output when the potential supplied to the input terminal **108A–D** is less than the potential supplied to the input terminal **110A–D**. Each comparator has an output terminal **126A–D** which will provide a significant output when the potential supplied to the input terminal **108A** is greater than the potential supplied to the input terminal **110A–D**.

A programmer **128** has a first output terminal **130** which provides clock pulses, a second output terminal **132** which is energized during the cell test cycle, a third output terminal **134** which is energized during the plasma test cycle, and a fourth output terminal **136** which provides a print pulse, and a fifth output terminal **138** which provides a reset pulse. Each cell output AND gate **120A–D** has three input terminals, one coupled to the comparator output terminal **126A–D**, one coupled to the clock pulse output terminal **130**, and one coupled to the cell test cycle output terminal **132**. Each plasma output AND gate **122A–D** has three input terminals, one coupled to the comparator output terminal **108A–D**, one coupled to the clock pulse output terminal **130**, and one coupled to the plasma test cycle output terminal **134**. Terminal **134** is also coupled to the relay solenoid **114**.

Four flip-flops **140A–D** are provided to store the information provided by the cell test cycle, and four flip-flops **142A–D** are provided to store the information provided by the plasma test cycle. The output terminal of each cell output AND gate **120A–D** is coupled to the input set terminal of the respective flip-flop **140A–D**. The output terminal of each plasma output AND gate **122A–D** is coupled to the input set terminal of the respective flip-flop **142A–D**. The input reset terminal of each of the eight flip-flops **140A–D** and **142A–D** is coupled to the reset pulse terminal **138**.

Five output AND gates **144A–E** are provided to characterize the results of the tests on each total sample of blood. Alternatively, the gate **144A** will provide an output signal in the case of type AB blood, the gate **144B** in the case of type A blood, the gate **144C** in the case of type B blood, the gate **144D** in the case of type O blood, and in conjunction with the foregoing, the gate **144E** will provide an output in the case of type D or Rh positive blood. The input terminals of these AND gates are coupled by a matrix to the output terminals of the flip-flops **140A–D** and **142**; and to the output terminal **146** of an inverter **148**. Six error AND gates **150A–F** have their input terminals also coupled by this matrix to the output terminals of the flip-flops, each of the gates providing an output in the event of two mutually inconsistent inputs thereto. The output terminals of the error AND gates **150A–F** are coupled to the input terminals of an error or gate **152** where output terminal **154** is coupled to the input terminal **156** of the inverter **148**. Thus, in the event of no inconsistency in the relative states of the flip-flops **140A–D** and **142A–D** there will not be any output signal from the error AND gates **150A–F** and no

output signal from the error OR gate **152**. The inverter will then provide a signal to the inputs of the characterizing AND gates **144A–E**. If there is an error output signal, the inverter will not provide an output signal, and each of the characterizing gates will be precluded from providing an output signal.

Five printers **160A–E** may be provided to print tags for attachment to the main blood containers **64'**. Each of these printers has a single element to print a blood type character, "AB," "A," "B," "O" and "Error," respectively. Each of these printers has a dual element to normally print "—" as indicative of Rh—, and, when energized, to print "+" as indicative of Rh+. Finally each of these printers has a set of numerical print elements and a code converter input therefor to print the identification number of the particular blood sample. The output terminal **158** of the Rh AND gate **144E** is coupled to the dual element in each of the printers, and the output conductors **161** readout mechanism **42'** are coupled to the code converter of each of the printers.

Five print relays are provided, each having a solenoid **162A–E** and a respective normally open contact assembly **164A–E**. The output terminals of the characterizing AND gates **144A–D** are respectively coupled to the print relay solenoids **162A–D**; and the output terminal **154** of the error OR gate **152** is coupled to the print relay solenoid **162E**. The input of each of the contact assemblies **164A–E** is coupled to the print signal output terminal **136** of the programmer **128**. The output of each of the contact assemblies **164A–E** is coupled to the overall printing actuator mechanism of the respective printer **160A–E**.

In operation, the red blood cells and the plasma are concurrently aspirated from a given sample container **16'** by the off-take mechanism **22'** as a stream, the red blood cells are cleansed, diluted and divided into four substreams, and the plasma is also divided into four substreams. Each of the streams is mixed with a reagent comprising an appropriate one of the group of antibodies, antigens and saline previously discussed.

Any agglutinated red cells are removed from each stream and each stream is lysed to provide a homogeneous color from any remaining red blood cells therein. The plasma streams are delayed, in phase, so that the cell samples arrive at their respective flow cells first. At this time the terminal **132** of the programmer is energized and the optical density readings from the cell flow cells are compared with the threshold values established by the respective potentiometers **104A–D**, and the results fed through the AND gates **120A–D** to the flip-flops **140A–D**.

When terminal **130** provides a clock pulse, the plasma samples now arrive at their respective flow cells, and at this time the terminal **132** is deenergized and the terminal **134** is energized. The relay **114** is energized, transferring the movable contacts **112A–D** from the fixed contacts **116A–D** to the fixed contacts **118A–D**. The optical density readings from the plasma flow cells as now compared with the threshold values established by the repective potentiometer **106A–D**, and the results fed through the AND gates **122A–D** to the flip-flops **142A–B** when the terminal **130** provides a clock pulse. The AND gates **144A–D** determine whether the blood is type AB, A, B, or O, the AND gate **144E** determines whether or not the blood is type Rh+ or Rh—, and the AND gates **150A–F** and the OR gate **154** determine whether the status of the flip-flops are mutually consistent. The identification number is fed from the read-out mechanism **42'** to the identification number print wheels of each of the printers. If an error has not been made, and the blood is Rh+, the And gate **144E** energizes the "Rh+" print element in each of the printers, and one of the AND gates energizes its associated relay solenoid **162A–D**. If an error has been made, the OR gate **152** energizes its relay solenoid **162E**. When the print terminal **136** of the programmer provides a pulse, the transferred one of the contact assemblies **164A–E** couples the pulse to the appropriate printer which prints out the identification number and either the appropriate blood type including Rh factor, or "Error." When the reset terminal **138** provides a pulse, all of the flip-flops are reset and the apparatus is prepared for a new sample cycle.

The printed tags provided by the printers may be manually applied to the appropriate blood supply containers **64'**. It will be appreciated that the information from the gates **144A–E** and **152** may alternatively be fed to a data card punch similar to that shown as **56** in FIG. 1, together with the identification number provided by the read-out mechanism **42'**, to produce a data card. The data card may then be fed to a sorter similar to **58** to automatically print out on the blood supply containers as described with reference to FIG. 1. Alternatively, in lieu of the use of the single element to print a blood type character in each of the printers **160A–E**, a roll of preprinted tags may be used.

While we have shown and described preferred embodiments of the invention, it will be understood that the invention may be embodied otherwise than as herein specifically illustrated or described, and that certain changes in the form and arrangement of parts and in the specific manner of practicing the invention may be made without departing from the underlying idea or principles of this invention within the scope of the appended claims.

What is claimed is:

1. A system comprising: a plurality of sample containers, each of said sample containers bearing indicia identifying said sample container, and adapted to contain a sample therein; analysis means for analyzing a plurality of liquid samples and for providing an output signal responsive to the result of each analysis; off-take means for removing a quantity of sample from each of said sample containers and for supplying these samples to said analysis means as a continuous stream of seriatim samples; a plurality of supply containers, each of said supply containers bearing indicia identifying said supply container and correlating said supply container with one of said plurality of sample containers; means coupled to said analysis means for reading out the indicia identifying each said sample container, for reading out the indicia identifying said supply container, and for providing each supply container with indicia responsive to the results of the analysis of the substance in the correlated sample container.

2. A system comprising: a plurality of sample containers, each of said sample containers having a first elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said sample container with an identification number, and adapted to contain a sample therein; analysis means for analyzing a plurality of liquid samples and for sequentially providing an output signal responsive to the result of each analysis; off-take means for removing a quantity of sample from each of said sample containers and for supplying the samples to said analysis means as a continuous stream of seriatim samples; first read-out means for sensing said array of notches on said first elongated member of each sample container and for providing an identification signal responsive thereto; first recording means coupled to said first read-out means for digitally recording on a document an identification number responsive to the identification signal, and coupled to said analysis means for digitally recording on the document the result of the analysis performed on the sample taken from that read out sample container in correlation with the identification number.

3. A system comprising: a plurality of sample containers, each of said sample containers having a first elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said sample container with an identification number, and adapted to contain a sample substance therein; analysis means for analyzing a plurality of liquid

samples and for sequentially providing an output signal responsive to the result of each analysis; off-take means for removing a quantity of sample from each of said sample containers and for supplying the samples to said analysis means as a continuous stream of seriatim samples; first read-out means for sensing said array of notches on said first elongated member of each sample container and for providing an identification signal responsive thereto; first recording means coupled to said first read-out means for punching on a card an identification number responsive to the identification signal, and coupled to said analysis means for punching on the card the result of the analysis performed on the sample taken from that read-out sample container in correlation with the identification number.

4. A system comprising: a plurality of sample containers, each of said sample containers having a first elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said sample container with an identification number, and adapted to contain a sample therein; analysis means for analyzing a plurality of liquid samples and for sequentially providing an output signal responsive to the result of each analysis; off-take means for removing a quantity of sample from each of said sample containers and for supplying the samples to said analysis means as a continuous stream of seriatim samples; a plurality of supply containers, each of said supply containers having a second elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said supply container with an identification number which is correlated to the identification number of one of said sample containers; first read-out means for sensing said array of notches on said first elongated member of each sample container and for providing an identification signal responsive thereto; first recording means coupled to said first read-out means for digitally recording on a document an identification number responsive to the identification signal, and coupled to said analysis means for digitally recording on the document the result of the analysis performed on the sample taken from that read-out sample container in correlation with the identification number; and second read-out means for sensing said array of notches on said second elongated member of each supply container and for providing an identification signal responsive thereto; sorting means coupled to said second read-out means for sorting the sample container identification numbers recorded by said recording means for the identification number correlated to the supply container identification number sensed by said second read-out means, and for providing a resultant signal responsive and to the result recorded in correlation with the sorted-for sample container identification number; and second recording means coupled to said sorting means for recording on the read-out supply container a result number responsive to the result signal.

5. A system comprising: a plurality of sample containers, each of said sample containers having a first elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said sample container with an identification number, and adapted to contain a sample therein; analysis means for analyzing a plurality of liquid samples and for sequentially providing an output signal responsive to the result of each analysis; off-take means for removing a quantity of sample from each of said sample containers and for supplying the samples to said analysis means as a continuous stream of seriatim samples; a plurality of supply containers, each of said supply containers having a second elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said supply container with an identification number which is correlated to the identification number of one of said sample containers; first read-out means for sensing said array of notches on said first elongated member of each sample container, and for providing an identification signal responsive thereto; first recording means coupled to said first read-out means for punching on a card an identification signal, and coupled to said analysis means for punching on the card the result of the analysis performed on the sample taken from the read-out sample container in correlation with the identification number; second read-out means for sensing said array of notches on said second elongated member of each supply container and for providing an identification signal responsive thereto; sorting means coupled to said second read-out means for sorting the sample container identification numbers recorded by said recording means for the identification number correlated to the supply container identification number sensed by said second read-out means and for providing a result signal responsive to the result recorded in correlation with the sorted-for sample container identification number; and second recording means coupled to said sorting means for recording on the read-out supply container a result number responsive to the result signal.

6. A system comprising: a plurality of sample containers, each of said sample containers having a first elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said sample container with an identification number, and adapted to contain a sample therein; analysis means for analyzing a plurality of liquid samples and for sequentially providing an output signal responsive to the result of each analysis; off-take means for removing a quantity of sample from each of said sample containers and for supplying the samples to said analysis means as a continuous stream of seriatim samples; first read-out means for sensing said array of notches on said first elongated member of each sample container seriatim; and for providing an identification number signal in response thereto; buffer storage means coupled to said first read-out means for storing the signal responsive to each of said identification numbers, and coupled to said analysis means for storing in correlation with the respective identification number signal the signal responsive to the result of the analysis on the respective sample.

7. A system comprising: a plurality of sample containers, each of said sample containers having a first elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said sample container with an identification number, and adapted to contain a sample substance therein; analysis means for analyzing a plurality of liquid samples and for sequentially providing an output signal responsive to the result of each analysis; off-take means for removing a quantity of sample substance from each of said sample containers and for supplying the sample substances to said analysis means as a continuous stream of seriatim samples; a plurality of supply containers, each of said supply containers having a second elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said supply container with an identification number which is correlated to the identification number of one of said sample containers; first read-out means for sensing said array of notches on said first elongated member of each sample container seriatim, and for providing an identification number signal in response thereto; buffer storage means coupled to said first read-out means for storing the signal responsive to each of said identification numbers, and coupled to said analysis means for storing in correlation with the respective identification number signal the signal responsive to the result of the analysis on the respective sample; second read-out means for sensing said array of notches on said second elongated member of each supply container seriatim, and for providing an identification number signal in response thereto; sorting means coupled to said second read-out means for sorting the sample container identification numbers in said buffer

storage means for the identification number correlated to the supply container identification number sensed by said second read-out means and for providing a resultant signal responsive to the result recorded in correlation with the sorted-for sample container identification number; and second recording means coupled to said sorting means for recording on the read-out supply container a result number responsive to the result signal.

8. A system comprising: a plurality of sample containers, each of said sample containers having a first elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said sample container with a unique identification number, and adapted to contain a sample therein; analysis means for sequentially analyzing a plurality of liquid samples and for providing output signals responsive to the results of each analysis; off-take means for removing a quantity of sample from each of said asmple containers and for supplying the samples to said analysis means as a continuous stream of seriatim samples; a plurality of supply containers, each of said supply containers having a second elongated member attached thereto, which member has a plurality of notches in an edge thereof in a combinational array providing said supply container with an identification number which is identic to the identification number of one of said sample containers; first read-out means for sensing said array of notches on said first elongated member of each sample container seriatim, and for providing an identification number signal in response thereto; buffer storage means coupled to said first read-out means for storing the signal responsive to each of said identification numbers, and coupled to said analysis means for storing in correlation with the respective identification number signal the signals responsive to the results of the analyses on the respective sample; logically operating means coupled to said buffer storage means for performing a logical operation on the signals representative of the results of the analyses of each sample, and providing a signal responsive to the result of the logical operation, and a correlated signal responsive to the identification number of the sample on which these analyses were performed; additional storage means coupled to said logically operating means for storing the signal responsive to the identification number of each of said samples and the signal responsive to the result of the logical operation concerned with that sample; second read-out means for sensing said array of notches on said second elongated member of each supply container seriatim, and for providing an identification number signal in response thereto; sorting means coupled to said second read-out means for sorting the sample container identification numbers in said additional storage means for the identification number correlated to the supply container identification number sensed by said second read-out means and for providing a result signal responsive to the result recorded in correlation with the sorted-for sample container identification number; and second recording means coupled to said sorting means for recording on the read out supply container result indicia responsive to the result signal.

9. A system comprising: a plurality of sample containers, each adapted to contain a sample therein; analysis means for contemporaneously analyzing a plurality of portions of each sample of a plurality of seriatim samples; means for conveying the samples from their containers seriatim to said analysis means; said analysis means providing a plurality of signals respectively responsive to the results of the analyses of the plurality of portions of each sample; and logic means for correlating the signals provided by said analysis means for each sample and providing a signal responsive to such correlation; said analysis means and said logic means operating seriatim upon each sample.

10. A system comprising: first means for providing a plurality of unique samples; analysis means for contemporaneously analyzing a plurality of portions of each sample of a plurality of seriatim samples; means for conveying samples from said first means seriatim to said analysis means; said analysis means providing a plurality of signals respectively responsive to the results of the analyses of the plurality of portions of each sample; logic means for correlating the signals provided by said analysis means for each sample and providing a signal responsive to such correlation; said analysis means and said logic means operating seriatim upon each sample.

11. A system comprising: first means for providing a plurality of unique samples; analysis means for contemporaneously analyzing a plurality of portions of each sample of a plurality of seriatim samples; means for conveying samples from said first means seriatim to said analysis means; said analysis means providing a plurality of signals respectively responsive to the results of the analyses of the plurality of portions of each sample; logic means for correlating the signals provided by said analysis means for each sample and providing a signal responsive to such correlation; said analysis means and said logic means operating seriatim upon each sample; recording means coupled to said logic means for recording the correlation responsive signal.

12. A system comprising: first means for providing a plurality of unique samples; means for providing a signal identifying each sample; analysis means for contemporaneously analyzing a plurality of portions of each sample of a plurality of seriatim samples; means for conveying samples from said first means seriatim to said analysis means; said analysis means providing a plurality of signals respectively responsive to the results of the analyses of the plurality of portions of each sample; logic means for correlating the signals provided by said analysis means for each sample and providing a signal responsive to such correlation; said analysis means and said logic means operating seriatim upon each sample, and coupled to said identification signal providing means for recording the identification signal in correlation with the correlation responsive signal.

13. A system comprising: a plurality of sample containers, each of said sample containers having a plurality of indicia thereon in a combinational array providing said sample container with an identification number, and adapted to contain a sample therein; analysis means for analyzing a plurality of samples and for sequentially providing an output signal responsive to the result of each analysis; means for obtaining a quantity of sample from each of said sample containers and for supplying the samples to said analysis means as a continuous stream of seriatim samples; a plurality of supply containers, each of said supply containers having a plurality of indicia thereon in a combinational array providing said supply container with an identification number which is correlated to the identification number of one of said sample containers; first read-out means for sensing said array of indicia on each sample container and for providing an identification signal responsive thereto; first recording means coupled to said first read-out means for digitally recording on a document an identification number responsive to the identification signal, and coupled to said analysis means for digitally recording on the document the result of the analysis performed on the sample taken from that read-out sample container in correlation with the identification number; and second read-out means for sensing said array of indicia on each supply container and for providing an identification signal responsive thereto; sorting means coupled to said second read-out means for sorting the sample container identification numbers recorded by said recording means for the identification number correlated to the supply container identification number sensed by said second read-out means, and for providing a resultant signal responsive to the result recorded in correlation with the sorted-for sample container identification number; and second recording

means coupled to said sorting means for recording on the read-out supply container a result number responsive to the result signal.

14. A system comprising: a plurality of sample containers, each of said sample containers having a plurality of indicia thereon in a combinational array providing said sample container with an identification number, and adapted to contain a sample therein; analysis means for analyzing a plurality of samples and for sequentially providing an output signal responsive to the result of each analysis; means for obtaining a quantity of sample from each of said sample containers and for supplying the samples to said analysis means as a continuous stream of seriatim samples; first read-out means for sensing said array of indicia on each sample container seriatim; and for providing an identification number signal in response thereto; buffer storage means coupled to said first read-out means for storing the signal responsive to each of said identification numbers, and coupled to said analysis means for storing in correlation with the respective identification number signal the signal responsive to the result of the analysis on the respective sample.

15. A system comprising: a plurality of sample containers, each of said sample containers having a plurality of indicia thereon in a combinational array providing said sample container with an identification number, and adapted to contain a sample substance therein; analysis means for analyzing a plurality of samples and for sequentially providing an output signal responsive to the result of each analysis; means for obtaining a quantity of sample substance from each of said sample containers and for supplying the sample substances to said analysis means as a continuous stream of seriatim samples; a plurality of supply containers, each of said supply containers having a second elongated member attached thereto, which member has a plurality of indicia thereon in a combinational array providing said supply container with an identification number which is correlated to the identification number of one of said sample containers; first read-out means for sensing said array of indicia on each sample container seriatim, and for providing an identification number signal in response thereto; buffer storage means coupled to said first read-out means for storing the signal responsive to each of said identification numbers, and coupled to said analysis means for storing in correlation with the respective identification number signal the signal responsive to the result of the analysis on the respective sample; second read-out means for sensing said array of indicia on said second elongated member of each supply container seriatim, and for providing an identification number signal in response thereto; sorting means coupled to said second read-out means for sorting the sample container identification numbers in said buffer storage means for the identification number correlated to the supply container identification number sensed by said second read-out means and for providing a resultant signal responsive to the result recorded in correlation with the sorted-for sample container identification number; and second recording means coupled to said sorting means for recording on the read-out supply container a result number responsive to the result signal.

16. A system comprising: a plurality of sample containers, each of said sample containers having a plurality of indicia thereon in a combinational array providing said sample container with a unique identification number, and adapted to contain a sample therein; analysis means for sequentially analyzing a plurality of samples and for providing output signals responsive to the results of each analysis; means for obtaining a quantity of sample from each of said sample containers and for supplying the samples to said analysis means as a continuous stream of seriatim samples; a plurality of supply containers, each of said supply containers having a plurality of indicia thereon in a combinational array providing said supply container with an identification number which is identic to the identification number of one of said sample containers; first read-out means for sensing said array of indicia on each sample container seriatim, and for providing an identification number signal in response thereto; buffer storage means coupled to said first read-out means for storing the signal responsive to each of said identification numbers, and coupled to said analysis means for storing in correlation with the respective identification number signal the signals responsive to the results of the analyses on the respective sample; logically operating means coupled to said buffer storage means for performing a logical operation on the signals representative of the results of the analyses of each sample, and providing a signal responsive to the result of the logical operation, and a correlated signal responsive to the identification number of the sample on which these analyses were performed; additional storage means coupled to said logically operating means for storing the signal responsive to the identification number of each of said samples and the signal responsive to the result of the logical operation concerned with that sample; second read-out means for sensing said array of indicia on each supply container seriatim, and for providing an identification number signal in response thereto; sorting means coupled to said second read-out means for sorting the sample container identification numbers in said additional storage means for the identification number correlated to the supply container identification number sensed by said second read-out means and for providing a result signal responsive to the result recorded in correlation with the sorted-for sample container identification number; and second recording means coupled to said sorting means for recording on the read-out supply container result indicia responsive to the result signal.

References Cited by the Examiner

UNITED STATES PATENTS

3,197,781	7/1965	Crouch	346—33
3,266,298	8/1966	Whitehead et al.	73—53

RICHARD B. WILKINSON, *Primary Examiner.*

J. W. HARTARY, *Assistant Examiner.*