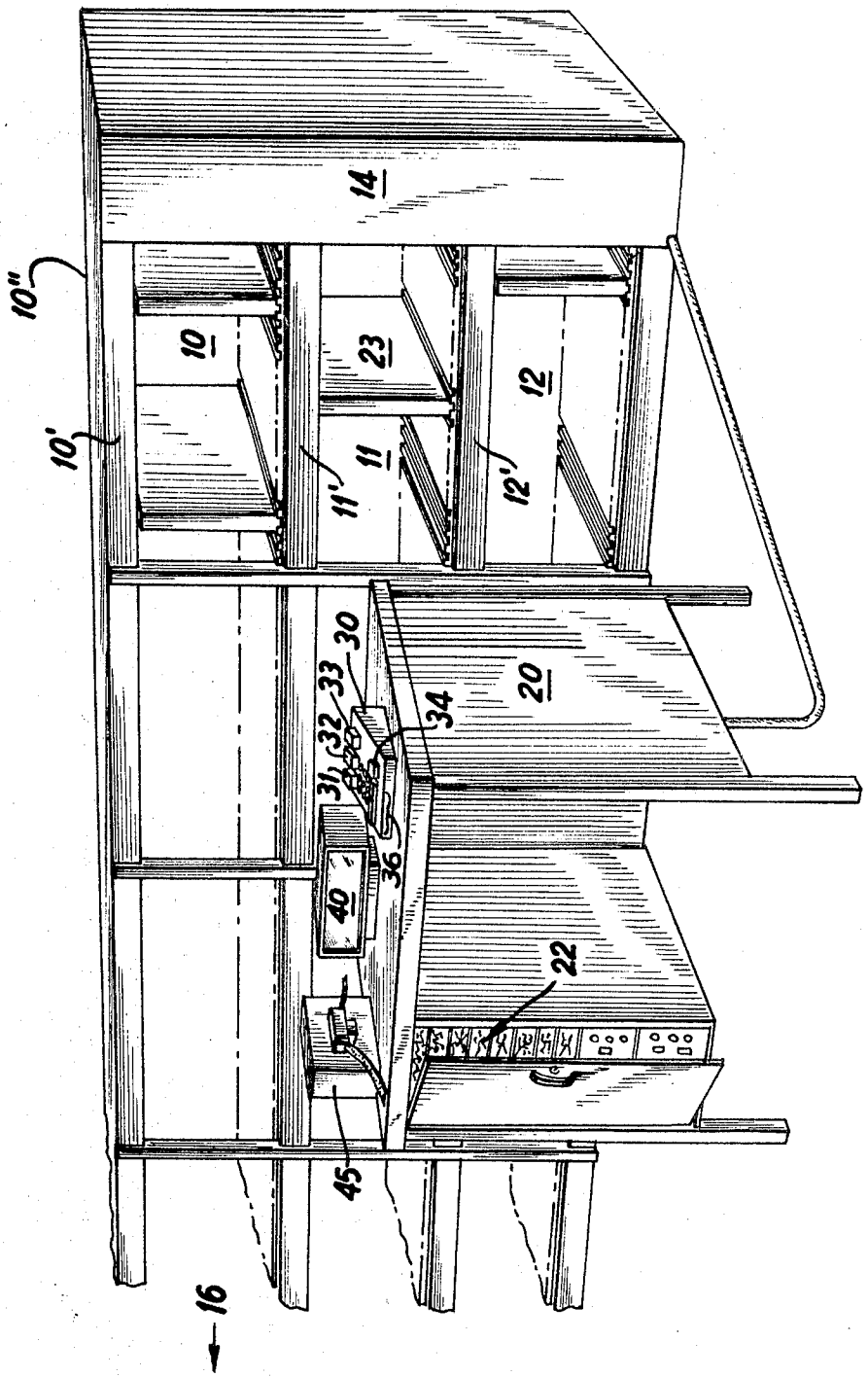
July 7, 1970 J. CASTALDI 3,519,832

READ HEAD ASSEMBLY FOR CODED MARKINGS

Filed Nov. 6, 1967 6 Sheets-Sheet 1

FIG. 1



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READ HEAD ASSEMBLY FOR CODED MARKINGS

Filed Nov. 6, 1967 6 Sheets-Sheet 2

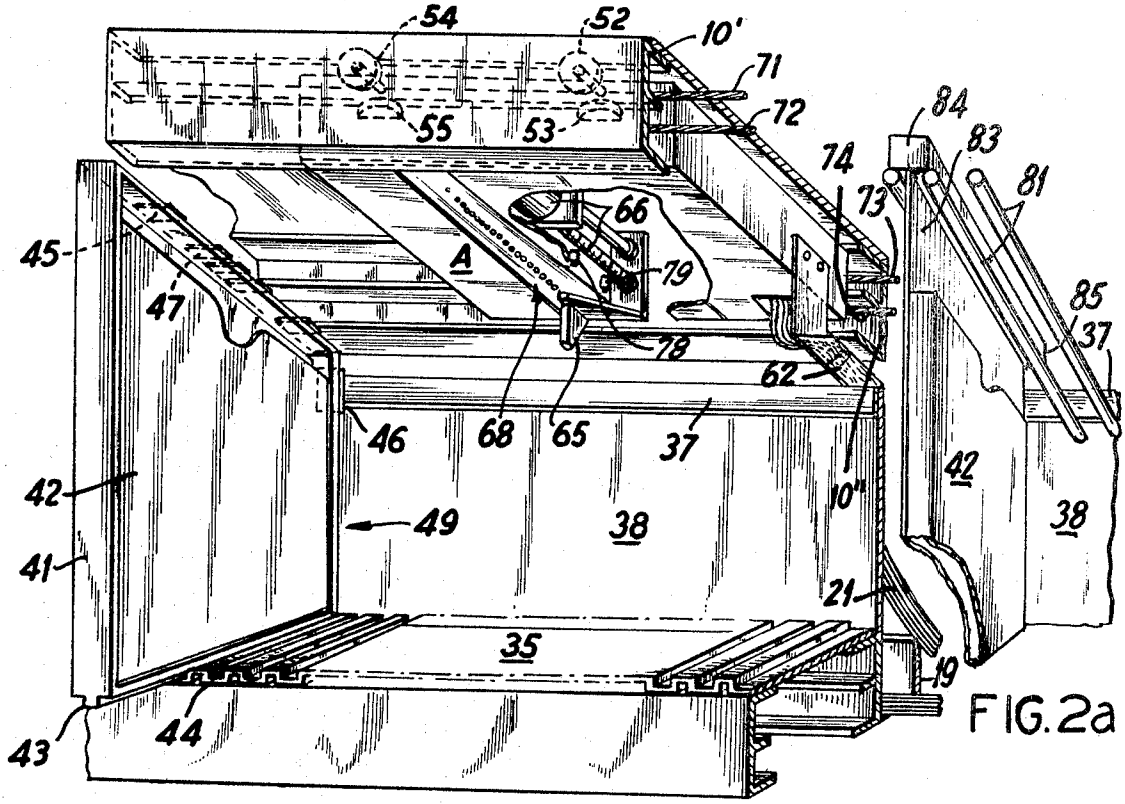

FIG. 2a

FIG. 2

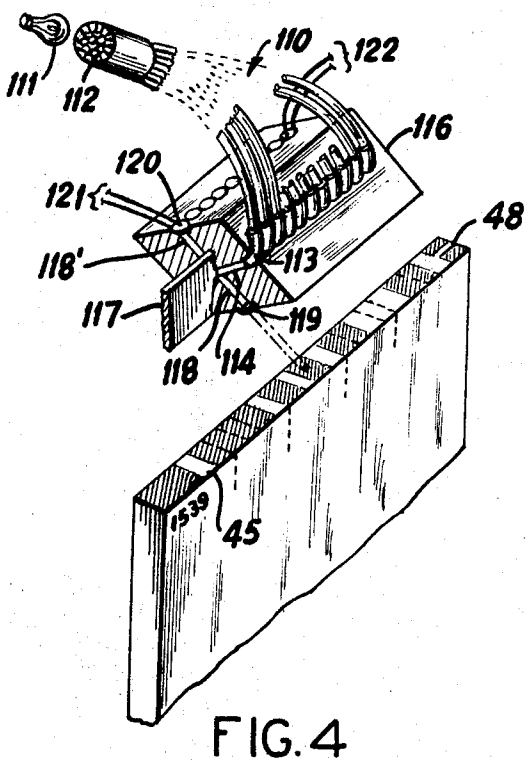

FIG. 4

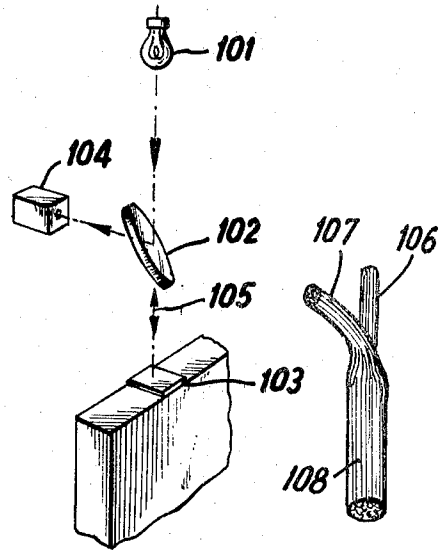

FIG. 3 FIG. 3a

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READ HEAD ASSEMBLY FOR CODED MARKINGS

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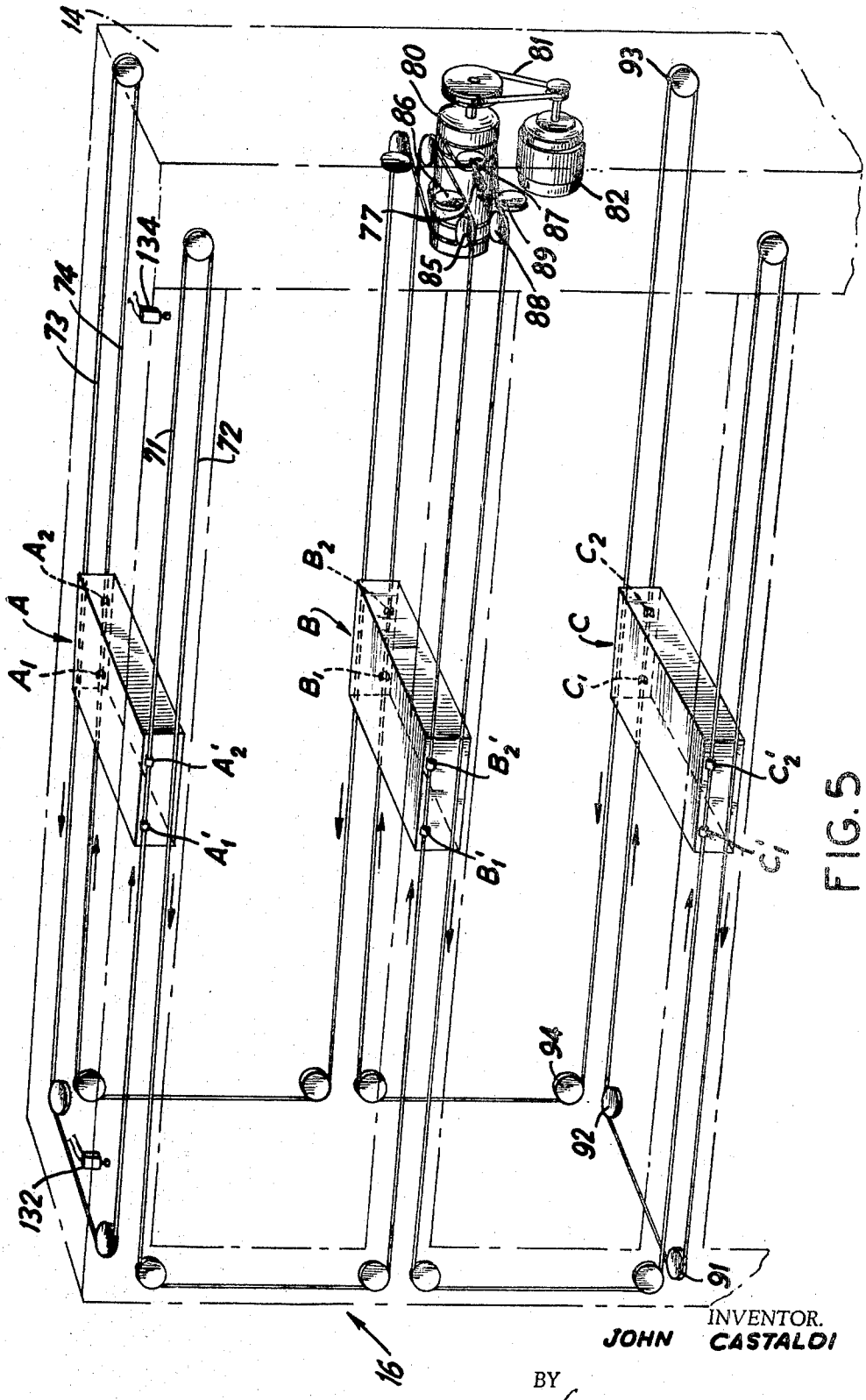

FIG. 5

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READ HEAD ASSEMBLY FOR CODED MARKINGS

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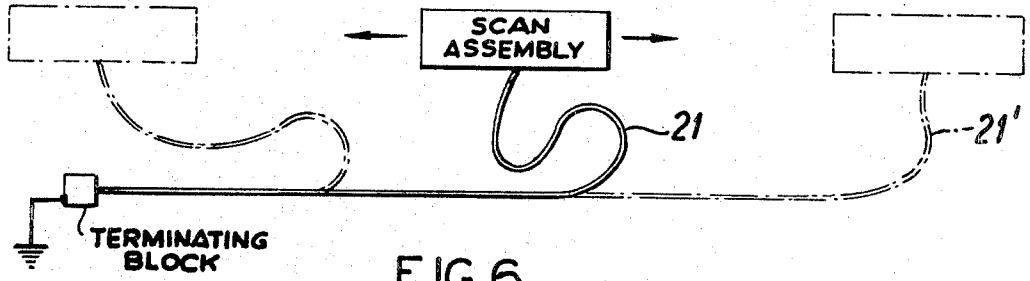

FIG.6

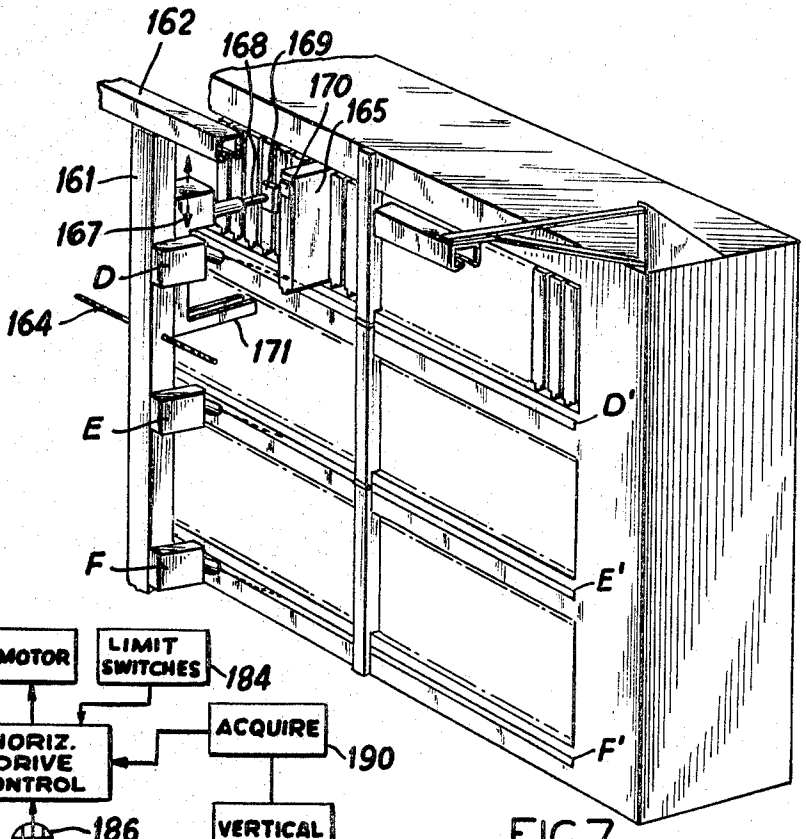

FIG.7

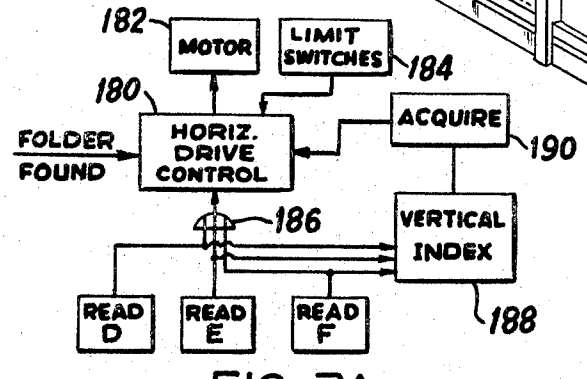

FIG. 7A

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READ HEAD ASSEMBLY FOR CODED MARKINGS

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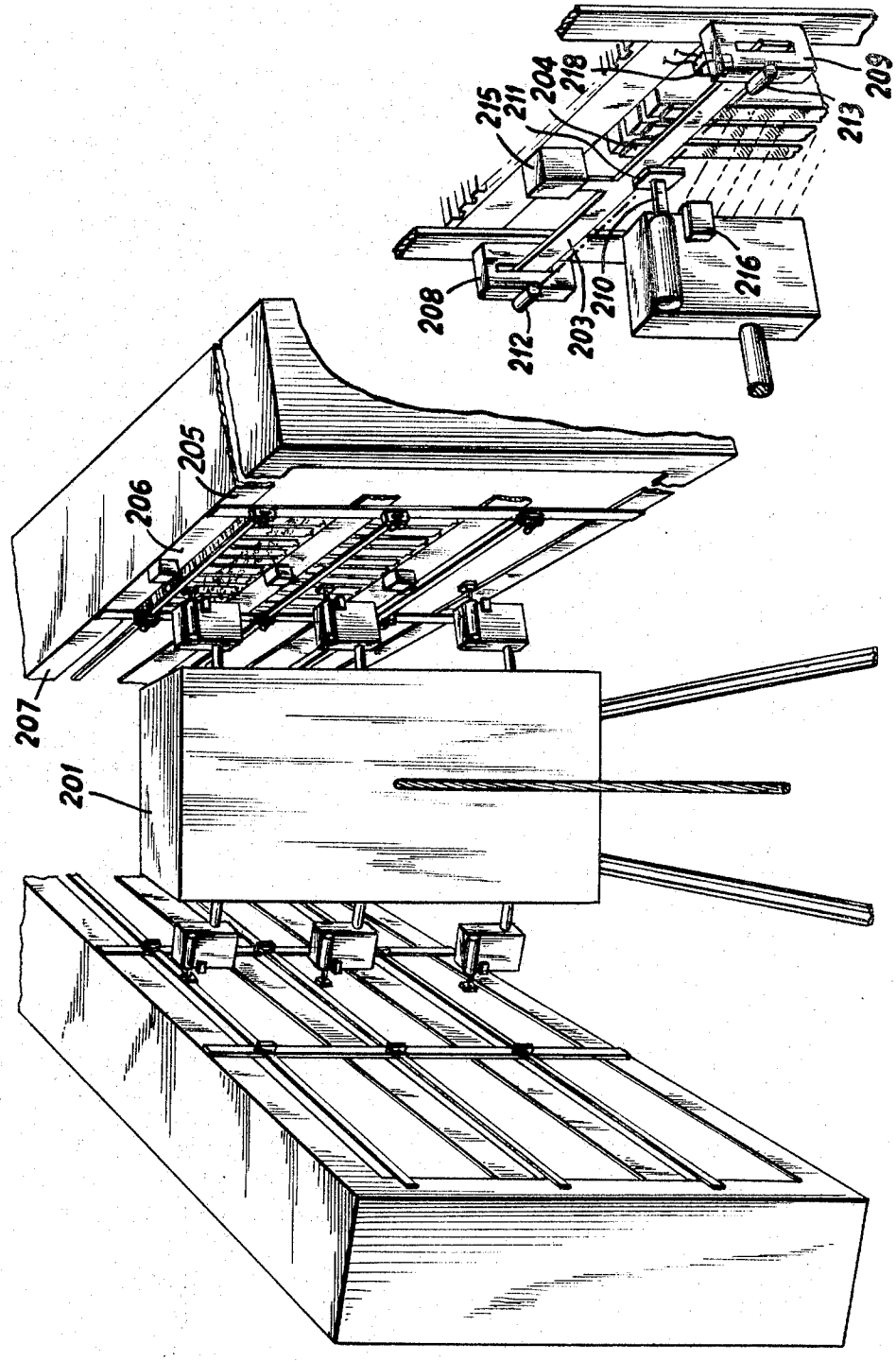

FIG. 8A

FIG. 8

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READ HEAD ASSEMBLY FOR CODED MARKINGS

Filed Nov. 6, 1967 6 Sheets-Sheet 6

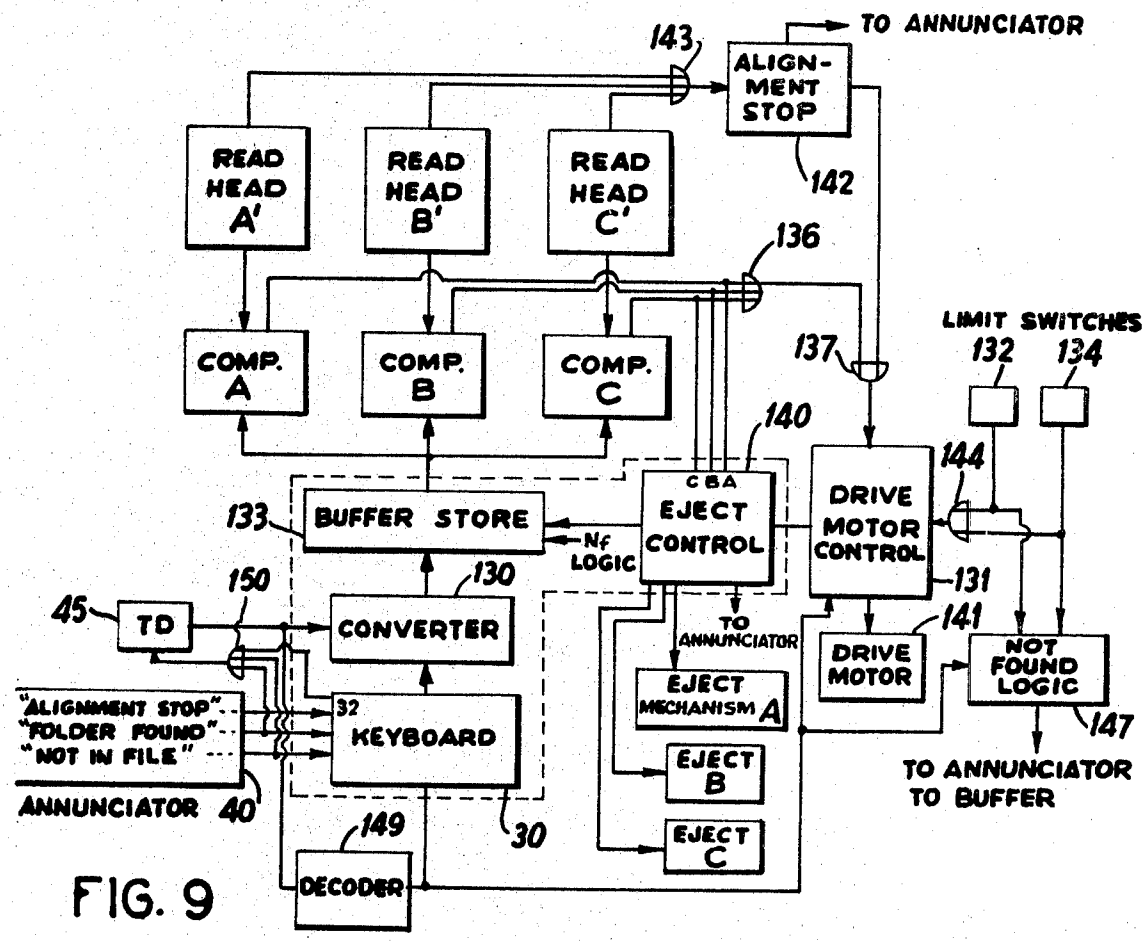

FIG. 9

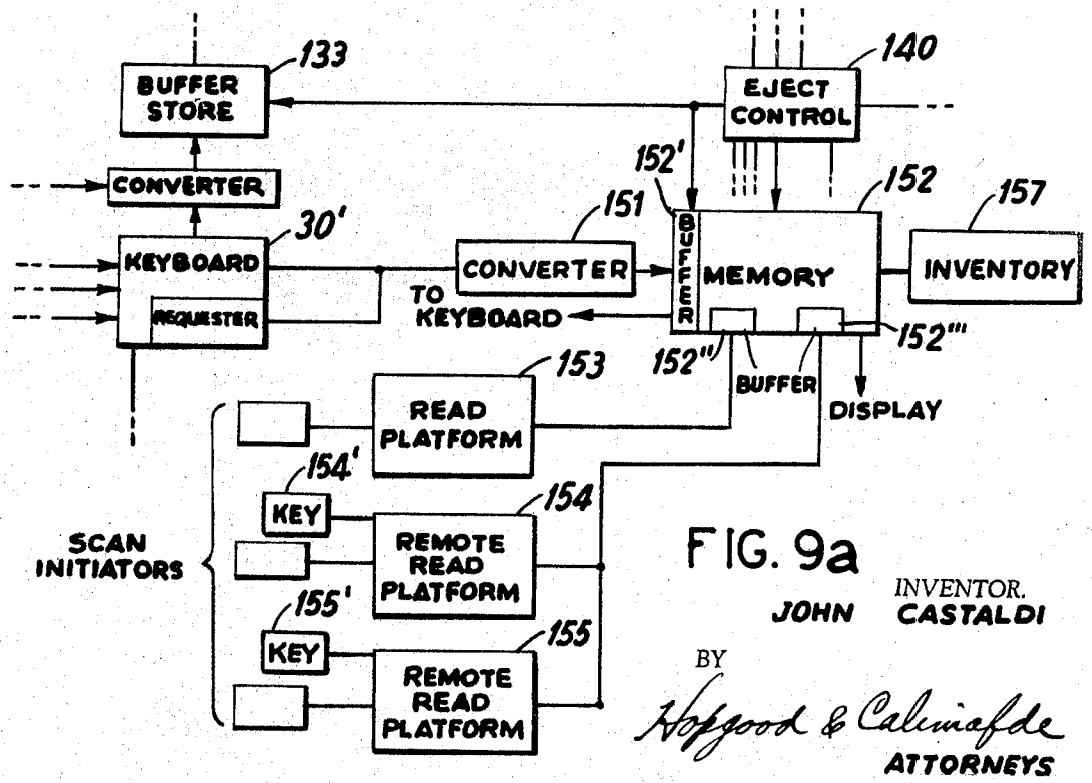

FIG. 9a

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United States Patent Office

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READ HEAD ASSEMBLY FOR CODED MARKINGS

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Continuation-in-part of application Ser. No. 430,330, Feb. 4, 1965. This application Nov. 6, 1967, Ser. No. 680,642

Int. Cl. G01n *21/26;* G02b *5/14*

U.S. Cl. 250—219 4 Claims

ABSTRACT OF THE DISCLOSURE

A random access store for cards, file folders and the like, in which the folders are stacked face-to-face. The folders are optically edge-coded and sensed simultaneously by a plurality of moving carriages, driven by a single cable, which continuously compares the sensed code to the command code and ejects the desired folder. The optical reader senses rectilinearly (along the same line as the light source) and the coded signal is automatically negated from mis-positioned folders. Folder alignment regardless of packing density is provided by magnetic clutching in cooperation with an array of folder guiding slots. Manual entry of the file folders into the store is random and may take place simultaneously with the automatic withdrawal. Towards this end, a feed-through access is provided which automatically gates and raises the magnetic clutches to permit ejection of the desired folder. Further refinements described include ejected folder collection; automatic input; a memory adjunct; and remote signalling.

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part to my copending application, Ser. No. 430,330, filed Feb. 4, 1965 and entitled "Automatic Locating Device."

BACKGROUND OF THE INVENTION

The present invention relates generally to data and information handling systems and more particularly to an apparatus for storing and retrieving information.

While it is possible to store large masses of information in conventional computer memories, such as matrices and drums, and even larger amounts of information on magnetic storage reels, it is often desirable, if not necessary, to resort to the document itself. Microfilming provides a partial solution but is unsatisfactory where production of the original is requisite. Examples abound in today's commerce and include commercial paper of all types, mortgages, deeds, stock, bonds, notes, proofs of audit, etc.

Additionally, entire files containing ten or a hundred or more pieces of paper may require review in the form of back-and-forth hunting which renders computer memorized information impractical.

As a consequence of the foregoing, in recent years there has arisen a number of systems capable of storing and retrieving information in its original form. While these arrangements partially obviate objections to stores of the information-memorizing type, many endeavors in this direction have created more problems than they have solved. For example, a majority of the original document-retrieving systems disposed the informations within storage racks at addresses memorized by a computer. The computer is then fed with the information denoting the desired document, and internally cross indexes to an address to which it directs a remote searching unit.

Where a large number of documents are involved, this type system is extremely cumbersome since each file must be returned to its proper address location. Hence, greater time is spent in returning the file than in obtaining it.

The documents may be filed at random and the search mechanism caused to scan each document face for an imprinted code number, e.g., magnetically or optically, and eject the sought document. This type of an arrangement requires a complex mechanical feed system in order to render visible an area on the face of each document sufficient to store and read the recorded number.

The most recent innovation in the latter type random access system is mechanisms capable of reading codes which appear upon the edge of the document or file. Since the codes may be magnetically or optically recorded, it is possible to scan the file edges at high speed. While these arrangements are an improvement over those recited earlier, they are still in their incipient stage and leave much to be desired in terms of speed, flexibility, alignment, edge-reading capability, document ejection, automation, synchronization and so on.

While the foregoing discussion has been directed primarily to original documents and file folders, it will be appreciated that it applies with like import to almost any material capable of being stored and acquired automatically. For purposes of simplicity, such materials shall be generically referred to hereinafter as "items."

OBJECTS OF THE INVENTION

It is the object of this invention to provide an improved random access storage system capable of identifying and acquiring items designated by specific code numbers recorded on the edge thereof.

It is a further object of this invention to satisfy the foregoing object with a system which is simple and economical to manufacture and maintain and which is sufficiently flexible in concept to permit adaptability to various types of stored items.

It is a further object of this invention to provide a sensing mechanism for the edge coatings which is accurate, reliable, and which is capable of being sufficiently remote to avoid interference with the mechanical functioning of the acquisition means.

It is a further object of this invention to increase the access speed in which the search mechanism finds and acquires the desired item.

It is a still further object of this invention to provide a random access storage system which may be simply and economically automated and functionally expanded.

SUMMARY OF THE INVENTION

Briefly, the invention is predicated upon the concept of providing an optical sensing mechanism capable of rectilinear scanning in such a manner that the read head always "sees" the coded area regardless of its distance and its orthogonal alignment within the stack. Access speed is doubled, quadrupled, etc., by the provision of a plurality of heads, simultaneously driven by a unique cable arrangement, searching respective aisles or stacks; the "acquiring" search head reporting back and being commanded to eject the item The items are magnetically clutched to maintain their attitude regardless of packing density and can therefore be depended upon to be posi-

tioned within predetermined limits. The magnetic mechanism may be repositioned automatically to permit simultaneous insertion and withdrawal of items from opposite sides of the stack.

Automation is provided by a return mechanism which acquires on the basis of read head sight interference by an ejected folder. Computer type memories are added which can store the present posture of items and can be remotely triggered to alter the memorized data to reflect a change in condition.

The above mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will best be understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, the description of which follows:

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective illustration of the exterior of a random access store in accordance with one embodiment of the invention.

FIG. 2 is a perspective detail of the file folder guide slots, magnetic clutch and scanning assembly of FIG. 1.

FIG. 2*a* illustrates an alternative arrangement for inserting edge alignment.

FIG. 3 schematically illustrates a single read head.

FIG. 3*a* shows a practical read head arrangement for achieving the same functional result as that shown in FIG. 3.

FIG. 4 is a perspective illustration of a sectioned read head assembly according to the invention.

FIG. 5 shows the cable assembly for synchronizing the scan assemblies.

FIG. 6 illustrates various positions in the umbilical cable linking a scan assembly to a terminating block in the storage rack.

FIG. 7 is a perspective illustration of an acquisition and file folder return mechanism which may be used in conjunction with the invention.

FIG. 7*a* is a block diagram illustrating the electronic control of the mechanism of FIG. 7.

FIG. 8 is a perspective illustration of a second embodiment of the invention wherein file folders may be acquired and inserted through opposing sides of the storage rack.

FIG. 8*a* is a perspective detail of a scanning assembly and rack portion in FIG. 8.

FIG. 9 is a block diagram of the electric circuits controlling the random access store according to the invention, and

FIG. 9*a* is a block diagram of a portion of the circuit shown in FIG. 9, modified to provide computerized functions.

DETAILED DESCRIPTION OF THE INVENTION

The general organization of the invention is shown perspectively in FIG. 1. For purposes of illustration, three vertically stacked racks **10**, **11** and **12** are shown. As will be appreciated from the description, any number of vertical racks may be simultaneously treated by the same control panel; further, these racks may be iterated horizontally.

The racks are separated by spacers **10'**, **11'** and **12'** which contain the scanning assemblies A, B and C (see FIG. 5). The rack ends abut the proximate and distally located end sections **14** and **16** which house the scanning assembly drive motors and transmissions (shown in detail in FIG. 5). The rack ends also include terminating blocks (such as generally referred to in FIG. 6) for coupling between the console **20** and the racks, and between stationary rack portions and the scanning assemblies. The scanning assemblies contain the scanning or read head assemblies and shuttle between the rack ends **14** and **16** via the opposing spacers (such as **10'** and **10''**, see FIG. 2) which act as guides. The assemblies are driven by a unique cable drive arrangement (as will be explained) which simultaneously advances the assemblies in each rack.

FIGS. 6 and 2 illustrate how communication is afforded between a rack terminal and the uppermost scanning assembly A. In the former figure, by use of phantom lines, the assembly is shown in three positions; middle, proximate, and distal. Since the scan assemblies which house the heads and associated ejection equipment travel the length of the system as shown, it is important to couple them electrically (via the rack ends) to the console in such a manner that the cable is played in and out without tension, regardless of the position of the scanning assembly.

Such an arrangement is provided as follows. Below each shuttle assembly is provided a trough **19** in which a ribbon-like multi-conductor cable **21** is laid (as shown in the figures) so as to double back on itself when the assembly advances to the cable termination in the rack end. To insure that a double back is initiated and the cable does not kink upon return of the head to the terminated end, a belly **21'** is allowed at the most distant scan assembly position. Ribbon cable **21**, upon exiting from the scanning head assembly A, is dressed along the L-shaped bracket **62** to a point above the trough **19** for permitting the double back cable lay-in as explained previously.

The described arrangement obviates contact noise normally associated with commutator type arrangements. It further obviates the problem of variable resistance as the head moves from one end to the other along a translator, and the necessity of pulleys at either end to maintain cable tension and position.

Console **20** is the functional hub of the system, and it is here that the operator sits when controlling the random access store. Preferably, the console contains the associated electronic equipment in module plug-in form (e.g., **22**) for ease in maintenance.

The console top includes a keyboard **30** having 10 numeric keys **36** for serial insertion of the code number representing the desired item. As will be explained hereinafter, the serial input is converted to a binary presentation, to a buffer storage device for comparison with the optically read signal emanating from the item scanning assembly.

Aside from the numeric digits, the keyboard also contains an "on-off" key **31**; a tape key **32** (whose function will be explained); a clear key **33** for negating errors in the number insertion; and a search key **34** for initiating the search once the desired number has been properly keyed in.

The console top also contains an annunciator **40** for indicating to the operator a variety of functions and machine conditions. For example, one annunciator expression would be "not in file" to indicate that the search has been completed unsuccessfully. Alternatively, "folder found" would be annunciated. Other indications to the operator would be "alignment stop" which, as will be explained, occurs upon the scanning of a misaligned folder, stopping the searching mechanism, so that the folder may be manually aligned to obviate errors. As the system is functionally expanded, additional annunciated phrases would be added.

The console top may also contain the tape reader **45**, commonly called a TD, for the automatic insertion of several code numbers representing several desired items. The TD may be any of the known types with conversion means being supplied to ensure coincidence with the numeric system being utilized. Magnetic tape, punched cards, etc., inputs may be used instead of a TD as will be apparent to those skilled in the art. A detailed explanation of the functioning of this equipment may be found hereinafter with reference to FIG. 9.

FIG. 2 illustrates the cooperation between the most sig-

nificant parts of the invention. A file folder **49** has been chosen as the "item." It comprises a plastic frame **41** having mounted therein an expandable insert **42** for adapting to variably thick records. The folder's configuration is generally rectangular save for a depending lip or fin **43** at the bottom of the folder for slidably engaging one of a series of closely spaced gullies **44** in the squared corrugated bottom of each rack **35**. The squared corrugations are formed of a hard, low-friction material and appear in edge view as repetitive square waves.

An elongated magnet **37** is mounted at the rear vertical wall **38** of each rack to run coextensive therewith. This magnet engages a metallic member **46** affixed to the rear side of the folder **49**. Upon insertion of the folder into the rack, the lower fin **43** first engages one of the gullies in the corrugated rack bottom, the rear of the folder then becoming secured magnetically to the back of the rack.

Thus, upon insertion of the full folder into the rack, it will maintain its initial position regardless of the density of the folders. That is, notwithstanding that the file folders may not be contiguous, they will maintain their initial attitude without falling over. In order to insure that the folder is not inserted in such a manner as to avoid engagement of the magnetic members, the fin **43** may be made sufficiently deep (as are the gullies **44**) so that the angular play of the folder top is reduced below that which would carry the metallic member **46** beyond reach of the magnet **37**. The foregoing arrangement obviates the folders attaining such an angle from orthogonal that the read heads on the scan assembly are unable to ascertain the information displayed on the folder top (although this angle has been found to be quite large).

An alternative arrangement is shown in FIG. 2*a* where a T-shaped member **83, 84** is affixed to insert **42** (which may now be deemed the "item"). The upper horizontal portion of the T, **84**, is sufficiently wide with respect to equi-spaced rods **81** that the item is caused to gravitationally depend from the rods. With this arrangement, the item may be easily slipped in and out of the rack. Magnet **37** and metal piece **85** can be included to provide a positive backstop, if desired.

The folder top or cross bar contains the optically coded information which describes the items. In the embodiment shown, it has been chosen to use four groups of binary digits (see dashed lines, FIG. 4), each representing one conventional base 10 digit. Each group of binary digits is made up of four areas each of which is either black or white, depending upon its informational content. A white area (e.g., **47**) represents the binary "one" and a black area binary "zero." Thus, the digital number 5 would be represented by black-white-black-white. Sixteen binary areas give a four conventional digit capability; i.e., the capability to store and search 9,999 file folders. Where this is sufficient, four more binary positions may be added to multiply the file storing capability by ten.

While straight numeric to binary conversion would permit greater permutations and hence a greater number of identified file folders per binary coded bit, the arrangement described has been found more convenient and more easily interpreted by the personnel involved.

The actual implantation of the areas may be simply effected by painting the top black or applying a piece of black tape over the top area to be scanned by the optical read heads and then applying a white reflective tape (e.g. **47**) at positions where binary "ones" are to be present. The preferred type of white reflective tape is one such as "Retroreflective" by 3 M Corporation which contains millions of non-aligned dispersed reflective surfaces so that regardless of which direction the incident light falls, reflection is assured in all directions.

Along with the code on the surface of the folder, there is included a so-called "read command" bit **48** (FIG. 4). This bit is simply a thin white area linearly aligned with the folder top and approximately centrally located between the folder edges. The bit may be placed anywhere in the binary but is preferably at the end of the code as shown. It is associated with a particular read head whose function is to trigger the reading of the entire head assembly. In other words, rather than depend upon the arbitrary triggering of the read heads one at a time as they view their respective area, one head is chosen which is unrelated to the binary code and which may trigger the entire read head assembly (in any well known manner) when the heads are centrally disposed with respect to the folder.

It will sometimes occur that a folder is not placed sufficiently far into the rack to engage against the magnetic back stop. When this happens, one of two situations will occur. Either the folder will only be slightly removed from its home position so that the heads will still read correctly, or the folder will be sufficiently removed from the home position so that bits will be misread. In order to obviate the latter event, a separate read head is offset a predetermined distance X from a white indicia area **45** which precedes the code.

The length X is that length within which the apparatus will still correctly analyze the folder regardless of slight misalignment. The width of the white indicia area **45** is that width within which an error will occur if the reading is taken upon issuance of a read command signal by the head associated with area **48**. As will be appreciated by those versed in the art, the output from the read head associated with area **45** may be led to a logical "OR" circuit of the exclusive type in conjunction with the read command signal so that a read command signal is effectively negatived during misalignment.

When the folder juts out, beyond the area within which the area **45** may be "seen" by the associated read head, the dimensional relationships are such that the read command signal is also out of range of its associated head and the folder is treated by the apparatus as a normally ejected folder; i.e., it is not read. In other words, within the distance X reading is permitted and within the distance X plus the width of the bright area **45**, no reading will take place due to a negativing of the read command signal.

It may be noted that no skew type misalignment is contemplated and only misalignment in the rectilinear sense is treated. This arises because the rack height is chosen to be dimensionally insufficient to permit insertion of the folder in any other manner than with the folder fin in a gully.

The scanning assembly

The scanning assembly, an exemplary one of which is shown in FIG. 2, contains the file ejection mechanism **65, 66** as well as a plurality of linearly arranged read heads (generally depicted as **68**). The latter will be explained in greater detail in a subsequent portion of this specification. Each scanning assembly rides between a pair of E-cross section guides **10'** and **10''** (previously referred to in general terms as spacers), the central horizontal arm of the E providing bearing surfaces for four pairs of orthogonal guide rollers, the front two of which (**52, 55**) are shown.

Upon an effective comparison being made between the sought file folder and that recognized by the reading heads (in a manner to be described), the lever arm **65** is actuated to eject the file folder. Since it is the object of the ejection to leave the file folder jutting out a predetermined distance from the magnetic back stop, it has been found preferable to use a high torque, low speed drive. The reverse, a low torque, high speed drive has been found to be ineffective with heavy folders and over-effective, to the point of throwing the file folders off the racks, for light files.

The high torque, low speed combination may be effected by a motor-lead-screw combination **66** of the conventional type. A motor speed of approximately 6,000

r.p.m. with a lead screw pitch suitable to providing a lever advance of 10 inches per second has been found adequate both as to size and performance. Retrograde of the lever arm **65** and motor shut off are effected, for example, by limit switches **78** and **79** in the well known manner.

Shuttling of the scanning assembly between the rack ends is controlled by cables **71, 72, 73** and **74**. FIG. 5 traces a cable arrangement for simultaneously advancing three vertically aligned scanning assemblies from a single motor drive. Each of the scanning assemblies is supported in the manner previously described (not shown in FIG. 5) and are driven in common from a single drive drum **80** which in turn is driven, via the speed reducing pulley arrangement **81**, by motor **82.**

Starting, for example, at the lowermost cable position, the cable is led around pulleys **91** and **92** disposed in the rear rack end **16** to points C_1 and C_2 where it is affixed to the lower scanning assembly C (e.g., by crimping in a lanced assembly portion as shown). From the points of affixation, a cable is led around pulley **93** and is then free running through scanning assembly C to the orthogonally disposed pulley **94.** At the front portion of assembly C, the upper cable is affixed at points C_1' and C_2'; the lower cable is free running.

The arrangement is similar with respect to the upper scanning assembly A; the cable again being affixed to the scanning assembly at diagonally opposite points to drive the scanning assembly in the same direction.

The relationship of the main driving drum **80** to the cable is exemplified by the following. The cable affixed to scanning assembly B at points B_1' and B_2' is led around pulley **85** under idler-and-positioning pulley **86** 180° about the drum **80**, thence about idler **87**, another 180° about drum **80**, and thence via pulleys **88** and **89** free running through scanning assembly B. The rear end of scanning assembly B is similarly treated with respect to the driving drum **80** via corresponding rollers (shown partially). Idler **87** and its counterpart (not shown) at the front portion of the drum also serve, by varying their axial distance from the drum, as cable tensioning means. The tensioning may be simply effectuated by a turn screw **77.**

The described arrangement allows a single drive drum and cable to advance and retrograde a plurality of scanning assemblies. The use of one continuous cable avoids cocking and jamming of the assemblies in their guides due to unequal cable loads and unequal cable expansion. The use of the single drive further obviates the necessity for separate motor control systems which would multiply by an order of magnitude the auxiliary equipment.

The described arrangement permits the simultaneous and synchronous advancement of a plurality of scanning assemblies without cocking and jamming normally associated with long runs of driven equipment having a substantial transverse dimension.

The scan or read heads

One of the basic components of applicant's invention is the optical read head system. As previously discussed, the code may be in either alpha or numeric form with discrete areas, each viewed by a particular read head. As described, binary notation has been chosen as preferable with Retroreflective tape being applied to those areas where a binary one is to be indicated.

As indicated generally by the arrow **68** in FIG. 2, the optical read heads are formed into a linear array of sensing positions. FIG. 3 is a detailed schematic of one such sensing position. A source of illumination **101** transmits its light through a semi-transparent mirror **102** onto file folder area **103.** If this particular area is coded with the Retroreflective tape, light is reflected off the surface back up to the semi-transparent mirror **102** where it is reflected to transducer **104** which converts the light energy into electrical energy. It has been found preferable to have the light source and transducer on orthogonal axes with the semi-transparent mirror being at 45° to each of these axes. The surface to be analyzed may be along either of these axes.

The described arrangement provides a very significant advantage. The incident and reflected light beams are substantially along the same path **105.** Consequently, regardless of the distance between the folder and the sensing device (presuming reflected light is above the noise threshold of the transducer) sensing may take place. Further, as will be described, axis **105** need not be perpendicular to the plane of the reflected area **103.** Consequently, the read heads may be angled to view an area in advance of the scanning mechanism, thus allowing for great flexibility in the positioning of the ejection lever, vis-a-vis the scanned file folder.

A similar functional result is achieved by the arrangement in FIG. 3*a*. A pair of fiber optic bundles **106** and **107** are joined into a common bundle **108,** which presents a common spatial area (the face of bundle **108**) through which transmitted and reflected light pass. The photocell (or generally "photo transducer") and light source **101** and **104** may be interchangeably directed to the ends of bundles **106** and **107.** Preferably the fiber strands of the two bundles should be interspersed to ensure a greater area of acceptance of reflected light. As will be described with respect to FIG. 4, a plurality of fibers **106** and **107** may be "commoned" to a single light source. The arrangement of FIG. 3*a* has the advantage that the angle of joining of bundles **106** and **107** is not critical.

FIG. 4 is a perspective illustration of a preferred scan head array for use in the invention. Rather than employing individual light sources, a single light source **111** is directed onto the planar face **112** of a fiber optic bundle **110.** Each of the fibers optic strands is led through a force fitting sleeve **113** into a linear channel **114** in block **116.** A rectangular semi-transparent mirror **117,** the half-silvered side of which is directed toward the file folder, is disposed at 45° within a channel cut for that purpose in block **116.** A portion of the light from the optic fiber strikes the surface of the mirror **117** and is reflected through channel **118** and focusing lens **119** onto the surface of the file folder. Light reflected from the surface passes through lens **119,** channel **118** (a portion of which **118'** is on the other side of the semi-transparent mirror **117**) and onto the transducing photocell **120;** where a signal representing the energy transmitted from the top of the file folder appears as electric energy on leads **121.**

Block **116** which is preferably cut from a black body or is later painted black includes a number of pairs of channels **118** and orthogonal channels **113** equal to the number of areas to be evaluated. The output of photocells **121** is lead through conventional threshold limiting and amplifying circuits (not shown) to a comparator as will be explained.

The deserибed arrangement permits the introduction of a great number of read heads within a very small area while the single source concept obviates the possibility of individual sources burning out and producing wrong indications when white areas are reported back as black.

Operation

The typical operation for the random access store according to the invention will now be described with reference to the circuit block diagram of FIG. 9 in conjunction with those figures previously discussed. In order to aid the reader, that figure which best depicts the component under consideration will be added in parentheses.

In order to extract the desired file folder from among the vertically aligned racks, keyboard **30** is actuated by serially depressing keys **36;** each of which is assigned to a numeral from 0 through 9. Each numeral impression is forwarded to a decimal to binary converter **130** where the series decimal presentation is converted into a parallel binary form.

Circuit **130** could be any of the well known types of decimal to binary converters, and thus will not be discussed at length. The subsequent depression of "Search" key **35** simultaneously triggers drive motor control circuit **131** and causes the converted code to be entered in a buffer store **133**. It is the function of the buffer store to permit a comparison between the codes being ascertained by the read head assemblies and the entered code designating the desired folder. Accordingly, the buffer store may, for example, comprise a simple matrix of ferrite cores to be interrogated by the comparators in a conventional manner.

If the number being inserted has been incorrectly entered, the operator may press a "clear" key **34** which will erase the buffer store and permit the reintroduction of the correct number.

As mentioned, key **35** also initiates the drive motor control circuit **131** thereby driving each of the scanning assemblies A, B, and C as shown in FIG. 5. Each of the read head assemblies A′, B′ and C′ is triggered in the manner previously described by the read command signal available at photocell **122** from each file folder (FIG. 4) and transmits a signal to the respective comparators A, B and C. This signal is a parallel binary presentation of the complete code designating that file folder.

When a comparison is effected by one of the comparators, the signal is employed via OR gates **136** and **137** to signal the drive motor control circuit **131**, and simultaneously set a relay corresponding to the comparator in the ejection control circuit **140**.

Since each of the scanning assemblies A, B and C includes considerable inertia, it is impractical for the drive motor and drive motor control circuit to be designed in such a manner as to instantaneously stop the scan. Rather, the comparator's signal is employed to reverse the voltage of D.C. drive motor **141**. Depending upon inertia considerations, this may be sufficient to permit the scanning assemblies (which have not speeded up greatly) to be stopped instantaneously by cutting off the drive motor voltage when a second comparison is effected in the reverse direction.

As will be appreciated by those skilled in the art, if the inertia of the scanning assemblies is too great and more damping must necessarily be introduced, then a reverse voltage may be applied only instantaneously followed by a lower voltage, thereby permitting the scanning assemblies to return to the overshot file folder at decreased speed. Alternatively, the scanning assembly may be permitted to overshoot the file folder again in the reverse direction, again reversing the voltage, and finally stopping at the desired file folder through a series of decreasing oscillations. Another arrangement would provide a second read head assembly on each scanning assembly. In this case, the first read head assembly to reach the desired folder would cause a decrease in speed allowing the scanning assembly to be stopped without direction reversal.

These and other methods will be apparent to those skilled in the art; since the instant invention is not dependent upon the precise manner in which the scanning assembly is stopped at the desired folder, and since precise control of D.C. motors is a well known art, these arrangements will not be discussed at greater length.

Presuming now that the scanning assembly has stopped at the desired file folder, the drive motor is now quiescent. This condition will be indicated to the ejection control circuit by the drive motor control circuit **131**. Since a relay corresponding to the particular read head has already been set, the corresponding ejection mechanism in scan assembly A, B or C may be actuated and via the motor lead screw arrangement shown in FIG. 2, the lever arm **65** progressed to project the file folder from the rack. The initiation of the ejection control circuit simultaneously triggers the annunciator to indicate "folder found" and erases the buffer store; thus permitting the operator to inject the next code designation into the equipment. A runner may now proceed down the aisle to pick up this folder.

If, in the manner described with reference to FIG. 4, one of the folders is out of alignment, jutting out a predetermined distance from the rack, this will be discerned by the read head assembly in the manner described and the alignment stop circuit **142** triggered through OR gate **143**. The alignment stop circuit in turn will cause the annunciation of the "alignment stop" phrase. The scanning assemblies meanwhile will come to a halt under the influence of the drive motor control circuit **131** signalled via OR gate **137** as previously explained. While the alignment stop circuit may take the form of a simple mechanical relay, a contactless transistor switching circuit would be preferred.

Limit switches **132** and **134** shown in FIGS. 5 and 9 are disposed at each end of the rack for engagement by one of the scan assemblies. The purpose of the limit switches is to reverse the direction of the scan assemblies when an excursion extreme has been reached. The limit switches are coupled to the drive motor control circuit **131** through OR gate **144** to effect this result.

A logic circuit **147** is coupled both to the keyboard search button **35** and limit switches **132** and **134**. When the scan has been initiated and thereafter the scan assemblies traverse both limit switches seriatum, this circuit will initiate the annunciated phrase "not in file." Logic circuit **147** may be of a simple AND/OR Boolean type whose logic is reinitiated each time search key **35** is depressed. The output of logic circuit **147** is also employed to erase buffer store **133** in a similar manner to that which would follow the energization of the ejection control circuit **140**.

Automatic input

Where a great number of file folders are being requested, it is often desirable to have the code numbers introduced automatically. To this end, a punched tape reader **45** (commonly called a TD) is provided at the console **20**.

Upon the insertion of the tape into the TD, a tape read input **32** on keyboard **30** is depressed initiating tape feed (via OR gate **150**) and the transmission of signals to a second input on converter **130** which is activated via button **32**. This second input is adapted to react to a different code (generally M out of N), but provides a similar binary presentation to the buffer store **133**.

Upon the occurrence of either the "folder found" or "not in file" signals, TD **45** again advances the tape by virtue of the signal appearing on OR gate **150**. At the head of each code designation, there is provided an arbitrary code to initiate the search. This code is recognized by a decoder **149** which initiates the scanning circuitry similarly to the keyboard search key **35**. The TD is programmed to stop at the end of each code designation and at the end of the tape (generally by providing informationless spaces).

When the folders have been collected and utilized in the manner desired, they may be replaced anywhere in the system where an open space exists. This is one of the most significant advantages of the random access system which reduces to an absolute minimum the time necessary to return a folder. With conventional file drawers, it must be remembered that the time it takes to return a folder is generally the same as that to find it in the first instance.

Automatic collection of ejected folders

FIGS. 7 and 7*a* illustrate a modification of the invention for automating the collection of the ejected file folders. The system is predicated upon the unique ability of the read head to view rectilinearly.

In front of each vertical array of racks, there is provided a standard **161** which is advanced between a pair of horizontal guide rails (only the upper one of which **162** is shown) via cable **164**. Standard **161** bears three in-

dividual read heads D, E and F angled downwardly at an acute angle to horizontal. Each of the read heads is directed to a strip of Retroflective tape (respectively D', E' and F') running the length of the rack.

When the collecting mechanism has been energized, and the manner in which this is accomplished and the attendant control arrangements will be discussed presently, standard **164** advances along the rack each of the heads D, E and F viewing their respective tapes.

An ejected file folder, for example folder **165**, will intercept the line of sight between the read head and the reflective tape. The reduction of photocell output below threshold is employed via an inverter circuit to produce a signal, causing the acquiring mechanism **167** to index over to that read head. Upon reaching its position, arm **168**, having at its end a magnet **169**, advances towards the top of the folder until it engages metallic piece **170**; affixed to each folder for the purpose of automatic collection. At this point which is coincident with the end of its travel, arm **168** automatically reverses drawing the folder out of the rack and onto the lower guide rail **171**. When arm **168** has been fully retracted, file folder **165** has cleared the rack and standard **161** may be advanced to either end of the storage area where the file folder is removed.

FIG. 7*a* shows a circuit block diagram for effecting the foregoing result. The "folder found" signal, which triggers the console annunciator, may be employed to initiate the horizontal drive control **180** which in turn causes motor **182** to advance standard **161** via cable **164**. Limit switches **184** (not shown in the perspective of FIG. 7) cause an automatic reversal of the drive when the folder-acquiring-standard reaches either end. Upon an ejected folder being ascertained by one of the read heads, the horizontal drive control is signalled through OR gate **186** to stop the scan. This may of course be in the same oscillatory or damped manner as described in conjunction with the stopping of the scanning assemblies. As soon as one of the read heads has recognized the ejected folder and before horizontal motion has stopped, vertical indexing of the acquisiton mechanism begins under control of the vertical indexing circuit **188**. This circuit is pre-programmed in any well known manner to one of three vertical positions. When it assumes any one of these positions, it automatically triggers the acquisition circuit **190** which in turn initiates the movement of the acquisition arm **168**.

Since solenoids, servo mechanisms, rachet and lead screw arrangements are all well known in the art, and each provides satisfactory results for driving the acquisition mechanism **167** vertically and acquiring arm **168** horizontally (depending upon the weight of the file folder, advancing speed, etc.) they will not be discussed further. Suffice it to say that limit and reversing switches are appropriately placed with respect to such mechanisms to achieve the desired functional result.

After the acquisition has been accomplished and the acquiring arm **168** has traversed both directions, acquisition circuit **190** triggers the horizontal drive control **180** to return the acquisition standard **167** in the desired direction to the point of collection or home position generally at one end of the rack. Unlike the scan assemblies where the initial direction of advance is left to chance, here the initial advance is always the same and the last or first motor control command must be to reverse direction.

Simultaneous ejection and folder return

Where the system described with respect to FIG. 7 is being used, it is hazardous to return file folders to the rack while the equipment is being used since slight miscalculation would certainly produce injury from the high speed standard.

The embodiment shown in FIGS. 8 and 8*a* obviates the foregoing problem and adds the significant advantage of simultaneous collection and return of folders from and to the system. In this embodiment, the code designations, rather than being written on the tops of the folders, are written on the sides where they can be viewed by scanning assemblies traversing in a direction similar to that described previously but orthogonally disposed in attitude. This permits the elimination of the scanning assemblies between the racks and increases the vertical rack area. As a practical matter, approximately a 25% saving is effected. The arrangement shown in FIG. 8 both conceptually and electrically works similarly to that described in connection with FIG. 9. Instead of three read head assemblies advancing simultaneously to read the folder tops (although the embodiment of FIG. 1 may be easily modified to any number of racks) six read head assemblies simultaneously scan the folder sides. Alignment problems are virtually eliminated with this arrangement since a horizontal displacement of a file folder is ineffective to promote erroneous readings. Thus, the alignment stop mechanism shown in FIG. 9 is not a necessary feature of this embodiment.

The file folders are inserted into the racks on the sides opposite to the traversing scan column **201** (the horizontal dimension of which has been exaggerated to permit the viewing of both racks simultaneously in the perspective). The folder is inserted with its coded area forward until it strikes magnetic bar **203**, which is engaged by a metallic piece **204** affixed to the folder.

Magnetic bar **203** rather than being continuous as was the previous case is segmented coextensive with each of the rack sections **205**, **206**, **207**, etc. Each magnetic bar rides slots in a pair of non-magnetic (for example, aluminum) guides **208** and **209** juxtaposed to similarly embrace the bar. When the scanning column had stopped opposite the designated file folder, the read heads, motor control circuit, etc. operate similarly to that previously described and ejection arm **210**, including a magnetic end piece **211**, advances toward the designated file folder directed at the metallic portion thereof. Arm **210** is controlled similarly to lever arm **65** by the ejection control circuit **140**. When arm **210** has progressed sufficiently to intercept a light beam communicating between source **212** and photocell **213**, a conventional inverter type circuit is actuated to energize solenoid **215** which retracts, picking up bar **203**. Arm **210** continues its course, engaging the magnetic stop **204** on the file folder and thereupon reverses, under control of the ejection control circuit, withdrawing the file folder from the rack.

Full seating of ejection arm **210** in its extreme retrograde position has resulted in the file folder being wiped off magnet **211** by the stop **216** mounted on each read head assembly.

Similar circuit functions and commands thereupon issue to initiate the next search. The withdrawal of arm **210** re-establishes the communication between the light source and photocell and de-energizes solenoid **215** permitting magnetic bar **203** to drop. Since the ejected file folder is now in the path, the bar will remain up until the folder is removed by a person collecting the folders.

Since an up position of the bar **203** would allow a folder inserted from the other side to pass completely through the rack or at the least assume an improper position horizontally, switch **218** is positioned to be closed upon the picking up of the bar. This switch is connected to a light on the reverse side of the rack to indicate to one replacing file folders to do so in another rack portion.

Thus, the embodiment of FIG. 8 permits not only a greater efficiency in the manual insertion and removal of file folders, but it also permits a greater savings of space. At this juncture, it must be remembered that the scanning standard **201** may have an extremely small horizontal dimension equivalent to that in FIG. 7.

It is also possible to combine the ejection mechanism of FIG. 8 to a withdrawal and collection mechanism similar to that shown in FIG. 7. To this end, it is possible

to cause the scanning heads to withdraw the file folders, not only the ejection distance, but fully off the rack thereafter pivoting 180° by means not shown and storing the file folders within column **201** (which will this time take a more box-like form).

The memory adjunct

This system may be functionally expanded simply and economically by means of a memory adjunct. The purpose of such an adjunct may be many-fold. First, it may contain a recapitulation of those files withdrawn from the system allowing a higher speed search to be initiated through the memory than can be physically accomplished by traversing the file folders. Thus, in a matter of a fraction of a second the memory could trigger the annunciation of "not in file." Second, the memory may serve the purpose of locating removed files by storing a code representative of the person who last requested the file folder. These and other functions will become apparent as the system is explained with respect to FIG. 9*a*.

FIG. 9*a* may be considered as a substituted block diagram for those blocks shown within the dotted lines in FIG. 9. When desiring to initiate a search for a particular file folder, the console operator keys in numerals designating the file folder, and also a code denoting the identity of the requester.This latter information may be provided by an auxiliary set of keys (not shown) or by serial keying in of a requester code. Upon initiating the search key in the manner previously described, the information is transmitted to converter **151** which presents the information in a manner acceptable to memory **152**. Memory **152** is for example, a multi-head, multi-track magnetic drum. The converted signal from keyboard **30'** is temporarily stored in a buffer portion **152'** of the drum (one track) in order to interrogate the memory with the code designation of the file folder. If the memory has no such number stored after a high speed scan, it signals the keyboard **30'** to initiate the search. This may be simply accomplished by triggering the keyboard search key.

When the file folder has been found and ejected via eject control circuit **140**, buffer store **133** will be erased in the usual manner under the control of the signal from the eject control **140**. This signal may be simultaneously employed to enter the content of buffer store **152'** associated with memory **152**, into the memory thereby storing the designation of the file folder and the requester.

Assuming now the same folder is requested, subsequently the interrogation of memory **152** will initiate a recognition of this file folder as one which had been removed. Memory **152** will thereupon issue a "display" signal which will simultaneously trigger the annunciation of "not in file" as well as an auxiliary annunciation of the person who has requested the file and now has it in his possession. This may be in either code form which may be referred to in a cross index or the annunciation may take place by means of a converter (not shown) to annunciate the person's name.

Upon return of the file to the storage rack, it is first placed on read platform **153** which contains an individual scan assembly. The placing of this file on the platform causes a scan initiator to traverse the read assembly over the file folder. The scan initiator may take the form of a photocell arrangement whose light is intercepted by a file folder thereby causing a read head assembly to traverse once over the file folder. Needless to say, a plurality of file folders may be simultaneously returned. Where the return is to be generally of single file folders, the read head assembly need not move. Rather, the file folder may be inserted between guides; automatically triggering a static read. The signals emanating from the read head assembly are transmitted to a second buffer **152''** within memory **152**. Memory **152** is automatically searched for the file folder code designation and erased to obviate the "not in file" annunciation.

Remote read platforms **154**, **155**, etc. may be placed at arbitrary locations. These read platforms are intended to modify memory **152** when a file folder is passed between persons without being returned to the rack. In such a case, the folder is placed upon the remote read platform and the number of the new file folder possessor keyed in on the associated key **154'**, **155'**, etc. This information is passed to buffer **152'''** of memory **152**; the memory being interrogated for an identical code designation and the code number of the new possessor of the file folder substituted.

The foregoing arrangement is particularly suitable to automatic inventory control. For this purpose, memory **152** may be provided with an inventory read out **157** which provides a complete print out of those file folders which are removed from the system as well as the names of the persons who possess the folders. The print out would be initiated and take place in a similar manner to conventional print outs from memories.

While the principles of the invention have been described in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention as set forth in the objects thereof and in the accompanying claims.

What is claimed is:

1. A read head assembly for scanning spatially aligned markings made up of code elements comprising:

a substantially rectangular block having a first plurality of channels spaced to correspond to the coded element spacings and communicating between said first and second opposing faces of said block;

a semi-transparent mirror angularly disposed in said block to similarly intercept each of said plurality of channels;

said block including a second plurality of channels each co-planar with a corresponding one of said first plurality of channels and intersecting said first plurality of channels at said mirror, said second plurality of channels communicating with a third face of said block;

point source means for directing light to each of the channels of one of said first and second plurality of channels and to the respective code element areas;

means for rendering all of said source means, one of active and inactive, simultaneously; and

a plurality of photo transducers, each disposed to intercept light from one of the channels of the other of said first and second plurality of channels.

2. The read head assembly claimed in claim **1** wherein said first and second plurality of channels are orthogonal with respect to one another and wherein said semi-transparent mirror is at an angle of 45° with respect to each of said first and second plurality of channels.

3. The read head assembly claimed in claim **1** wherein said point source means and rendering means comprises:

a remote light source; and

a fiber optic array having a bundled end adjacent said light source, the individual fibers being divided among said one of said first and second plurality of channels for the transmission of light thereto.

4. A read head assembly as claimed in claim **1**, wherein said point source means directs the light to said second plurality of channels and wherein said first plurality of channels are parallel and spaced by a distance equivalent to the code element spacings.

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