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(54) IMPROVEMENTS IN OR RELATING TO ACCESS-CONTROL EQUIPMENT AND ITEM-DISPENSING SYSTEMS INCLUDING SUCH EQUIPMENT

(71) We, SMITHS INDUSTRIES LIMITED, a British Company of Cricklewood Works, London, N.W.2, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to access-control equipment and item-dispensing systems including such equipment.

The invention is especially concerned with access-control equipment of the kind that selectively enables access to a facility, under control of a coded token. The coded token may, for example, be in the form of a punched card, each person authorized to make use of the facility being issued with such a card for presentation to the equipment when access is required.

According to the present invention, access-control equipment for selectively enabling access to a facility comprises first means for receiving a coded token presented to the equipment and for reading from the received token a plurality of numbers encoded thereon, second means for entering into the equipment a further number, third means that is selectively operable for enabling access to said facility, and fourth means that is arranged effectively to compare with the said further number the numerical result of a predetermined arithmetical operation that involves interaction upon one another of said numbers read from the token, said fourth means being arranged to operate said third means as aforesaid in dependence upon whether a predetermined correspondence exists between said numerical result and said further number.

The numbers read from the token may be plural-digit numbers that together relate to the identity of the particular person to whom the token has been issued, and said predetermined correspondence may be arranged to exist, and

access to said facility may be enabled, only if such person is also identified by a plural-digit number entered into the equipment manually. This arrangement has the advantage of increased security over certain prior access-control equipment (for which presentation of an appropriately-encoded token is normally all that is required in order to gain access to the relevant facility) since the gaining of access in these circumstances is conditional not only upon the presentation to the equipment of an appropriately-encoded token, but also upon manual entry of the corresponding plural-digit number. The possibility of the token being used fraudulently is reduced by having the information as to identity encoded in a form (a plurality of separate numbers that are together dependent upon the particular arithmetical operation used) that will not readily allow the corresponding plural-digit number to be deduced from the token alone or by comparison of the token with other similarly-encoded tokens.

The access-control equipment may be arranged to enable selectively, access to any form of facility, for example, entry to a restricted area, use of a service, or release of means enabling withdrawal of an item or product (in predetermined or selected quantity). One particular application of the equipment is in the field of banking where money-dispensing systems are provided for use by customers at all times, the customers being issued with individual coded-tokens for presentation to any one of the dispensing systems when withdrawal of money is required. The equipment of the present invention in this latter connection may be arranged to control a money-dispenser so that money (for example, in bank-note form) is dispensed to the customer in response to each 'request' for withdrawal, a 'request' in this context being the combination of the pre-

sentation to the equipment of the customer's token and entry of an appropriate number into the equipment. The system is preferably arranged such that the same amount of money, in the form of a single bank-note or a pack of bank-notes, is dispensed as a single item upon each 'request'.

According to a feature of the present invention, an item-dispensing system comprises means for receiving a coded token presented to the system and for reading from the received token a plurality of plural-digit numbers encoded thereon, means which is operable manually for entering into the system a further plural-digit number, the particular number entered being dependent upon manual selection, item-dispensing means which is selectively operable to dispense from a reserve of items at least one such item upon each operation of the item-dispensing means, and comparison means arranged effectively to compare with the said further number the numerical result of a predetermined arithmetical operation that involves interaction upon one another of said plural-digit numbers read from the token, said comparison means being arranged to operate said item-dispensing means to dispense at least one of said items as aforesaid in dependence upon whether a predetermined correspondence exists between said numerical result and said further number.

The means for entering a plural-digit number manually may include ten keys (for example, push-buttons) numbered 0 to 9 that are operable one at a time to enter the digits of the relevant number in ordered sequence. As an alternative, such means may include a dial mechanism comparable to a telephone dial, the relevant digits being entered, in order, by sequential dialling operations.

The arithmetical operation may be summation of the numbers read from the token, and in this respect may be summation-without-carry of those numbers. The comparison means may be arranged to compare digit-by-digit the numerical result of the operation with the plural-digit number entered manually. There may be, for example, N decimal numbers each of M digits (where M and N, which may be equal, are both integers greater than unity) read from the token, and in these circumstances the comparison means may include means for performing a subtraction process in respect of each digit of an M-digit decimal number that is entered manually one digit at a time in ordered sequence. The subtraction process may be a process in which there is subtracted from the value of the relevant entered-digit the values of N decimal digits that in the N decimal numbers respectively occupy one and the same digital place, the particular one of the digital places concerned being dependent upon the order of the entered-digit in the entry-sequence. In these circumstances it may be arranged that operation of the item-

dispensing means is enabled only in the event that the result of each of the M subtraction processes is zero.

An item-dispensing system in accordance with the present invention will now be described, by way of example, with reference to the drawings accompanying the Provisional Specification, in which:—

Figure 1 shows the form of a coded token used with the item-dispensing system;

Figure 2 is a schematic representation of part of the item-dispensing system used for receiving and selectively admitting coded tokens to the system; and

Figure 3 is a schematic representation of electronic circuits forming part of the item-dispensing system and used in conjunction with the arrangement of Figure 2.

The system to be described is for use in dispensing packets of bank-notes, one at a time, to customers of a bank, and is for installation at a branch of the bank to be accessible after, as well as during, normal banking hours. The customers authorized to use the system are each issued with one or more coded tokens in the form of plastics cards punched with holes. Each card carries numerical information identifying the customer to whom the card has been issued, such information being encoded on the card by the presence and absence of holes in predetermined positions on the card. The customer is informed of his personal-identification number, but the encoding of this number on the card is such that it cannot be readily deduced from the punched-card itself. When the customer wishes to withdraw a packet of bank-notes, he simply presents his punched-card to a card-reception unit of the system and operates a set of ten push-buttons in accordance with his personal-identification number. The system retains the card and in return automatically dispenses to the customer one packet of bank-notes. The packet of bank-notes is dispensed to the customer from a dispenser that holds a supply of such packets, the dispenser being released to dispense the packet only after the validity of the transaction has been checked. In this latter respect the system checks the authenticity of the card and then that the number inserted manually by the customer is the same as the personal-identification number encoded on the card.

Referring to Figure 1, each card is formed by a rectangular substrate 1 of opaque plastics material that carries a magnetic coating 2 on its obverse face (the coating may be sandwiched between two plastics sheets). In addition to holes 3 punched through the card to encode the appropriate personal-identification number, there is a set of three holes 4 that are punched through the card at spaced intervals from one another across the width at one end 5. The magnetic coating 2 involves two magnetic oxides of high- and low-coercivity respectively, the magnetic oxides being provid-

ed either in separate layers, with the layer of high-coercivity material extending in a band across the width of the substrate 1 beneath the other layer, or as an admixture of the two materials. A series of pulses is recorded in the high-coercivity material, the individual pulse-recordings being made at positions within the coating 2 spaced from one another lengthwise of the card. For security purposes, the low-coercivity material carries a magnetic recording that extends over substantially the whole area of the coating 2 and serves to provide 'noise' masking the pulse-recordings from easy detection.

The authenticity of each card presented to the system is checked, firstly by detecting whether the card has appropriately-located holes 4, and then by detecting whether it carries an appropriate series of pulse-recordings in the coating 2. These checks are performed by the card-reception unit represented in Figure 2.

Referring to Figure 2, the card-reception unit has a facia 10 that is mounted in an external wall of the bank, and has a readily-accessible mouth 11 for receiving the customer's card. The mouth 11 within the unit converges to a throat-portion 12 that is normally blocked at its far end by a movable shutter 13. An electrical solenoid 14 controls the shutter 13, the solenoid 14 when energized moving the shutter 13 upwardly against a spring-bias to bring a gate aperture 15 through the shutter 13, into alignment with the throat-portion 12. This opens the way for the card to pass through the portion 12 into a guideway 16 that leads to a card-reader 17. The shutter 13 remains in this open position only so long as the solenoid 14 is energized, and is otherwise returned and held by the spring-bias in the closed position in which the way into the guideway 16 is blocked.

The customer presents his card to the card-reception unit by inserting the end 5 into the exposed mouth 11 with the coating 2 uppermost. The end 5 is inserted through the mouth 11 into the throat-portion 12 to abut the closed shutter 13. In this position of the card, the set of holes 4 lie beneath lamps 18 (of which only one is shown) that are continuously energized to direct light downwardly across the throat-portion 12 towards individual photoelectric cells 19. The photoelectric cells 19 (of which only one is shown) are disposed at spaced intervals from one another across the width of the throat-portion 12, and, until a card is inserted in the throat-portion 12, each cell 19 receives light from its associated lamp 18 and in response thereto supplies an electric signal to an electrical gating unit 20.

The unit 20 is responsive only to the condition in which signals are supplied by a certain combination of three of the photoelectric cells 19 and not by the remainder. This condition exists only when a card with the corresponding

number of appropriately-located holes 4 is presented to the card-reception unit with the end 5 leading and with the coating 2 uppermost, light passing to the three cells 19 through the holes 4, and being obstructed in its passage to the remainder by the absence of holes 4 elsewhere across the width. Response of the gating unit 20 to this condition is, however, effective to produce an output signal from the unit 20 only in the circumstances in which an enabling signal is present on a lead 21 from the dispenser (not shown in Figure 2) of the system. The dispenser supplies the enabling signal to the lead 21 only so long as there is still a packet of bank-notes available in the dispenser. If no enabling signal is present on the lead 21, there is no output signal from the unit 20, and an EMPTY sign (not shown) on the facia 10 of the card-reception unit is illuminated. The EMPTY sign is illuminated (by means not shown) throughout any period for which the enabling signal is absent from the lead 21, so as to warn customers that the system is not operative. The absence of the enabling signal at the unit 20 has the effect of inhibiting operation, since the system is then incapable of responding even when presented with an authentic card.

When there is response of the unit 20 in the presence of the enabling signal on the lead 21, the output signal supplied by the unit 20 is passed to switch ON a switch unit 22 that controls the supply of electrical energization current to switch ON a switch unit 23, to engage a clutch 24, and to start operation of a timer 25. The switch unit 23 controls the supply of electrical energization current to a reversible electric motor 26, the motor 26 being coupled through the clutch 24 to drive three card-transport rollers 27 to 29 that project into the guideway 16 at spaced intervals therealong. The switching ON of the units 22 and 23 serves to energize both the solenoid 14 and motor 26, with the result that the shutter 13 moves upwardly to admit the card through the gate-aperture 15 into the guideway 16, and the rollers 27 to 29 rotate in their forward senses indicated by the arrows F. The card admitted through the gate-aperture 15 is fed by the customer into the guideway 16 until the leading end 5 reaches the rotating roller 27. An idling roller 27¹ is urged resiliently and downwardly into contact with the roller 27 so that when the end 5 reaches the roller 27 the card is drawn lengthwise completely into the card-reception unit. The card is drawn in between the rollers 27 and 27¹ to be fed along the guideway 16 towards the rotating roller 28. The end 5 eventually enters between the roller 28 and an associated idling roller 28¹ that is urged resiliently and downwardly into contact with the roller 28. The card is accordingly drawn lengthwise from the rollers 27 and 27¹ and is passed further on along the guideway 16 towards the rotating roller 29 po-

sitioned at the entrance to the card-reader 17.

The card, in its passage along the guideway 16 from the roller 27 to the roller 28 and thence from the roller 28 towards the roller 29, passes successively beneath a magnetic-recording head 30 and a magnetic-reading head 31. The head 30, which projects into the guideway 16 adjacent the roller 27, is energized with alternating current that is supplied from a source 32 to erase the 'noise' which in an authentic card is recorded over the pulse-recordings in the coating 2. The frequency and amplitude of this alternating current are so chosen that the magnetic flux produced by the head 30 is well capable of erasing the 'noise' recorded in the low-coercivity material, but is nonetheless insufficient to affect the pulse-recordings recorded in the high-coercivity material.

The erasure of the 'noise' masking the pulse-recordings enables these recordings to be read from the coating 2 by the head 31. The head 31 projects into the guideway 16 adjacent the roller 28, and as the card is fed lengthwise from between the rollers 28 and 28', so the pulse-recordings of the authentic card are sensed in turn by the head 31. The sensed pulse-recordings give rise to a series of pulse signals from the head 31, and these pulse signals are passed from the head 31 to a code-recognition unit 33 where they are counted. The unit 33 detects whether the number of pulse signals counted is the same as the number of pulse-recordings provided on each authentic card, and then only if it is, provides on a lead 34 an output signal indicative of this fact. This output signal, the existence of which (as explained later) is an essential for release of the dispenser to dispense a packet of bank-notes, persists after the card has passed on to the roller 29 and until the unit 33 is eventually reset.

The card in being driven by the roller 28 from the head 31 towards the roller 29, strikes a leaf-spring 35 that projects upwardly through a slotted opening 36 in the bottom of the guideway 16. The leaf-spring 35 is sprung to incline forwardly across the path of the card and so as to be deflected downwardly by the card in passage of the card along the guideway 16 to the roller 29, the deflected spring 35 effectively blocking entry to the opening 36. At the roller 29 the leading end 5 of the card is drawn in between the rotating roller 29 and an associated idling roller 29¹ that is urged resiliently and downwardly into contact with the roller 29. The card is accordingly drawn lengthwise through the rollers 29 and 29¹ so as to pass into the card-reader 17. From the roller 29 the card passes onto a bed 37, and beneath a head 38, of the card-reader 17. The card is driven by the roller 29 so that the end 5 passes along the full length of the bed 37 to strike a plunger 39 located at the far end of the bed 37. The drive provided

on the card by the roller 29 urges the plunger 39 backwardly against a spring 40 to actuate a switch 41.

Actuation of the switch 41 causes an electric signal to be supplied from the switch 41 to switch OFF the unit 22 and to terminate operation of the timer 25. The switching OFF of the unit 22 breaks the supply of energization current to the solenoid 14 with the result that the shutter 13 closes. The timer 25 is arranged to supply a signal to the unit 22 to have the same effect as this, in the event that a pre-set period of operation of the timer 25 expires before receipt of the signal from the switch 41. In this latter respect, the timer 25 is pre-set to run for a period adequate to allow the card to be transported along the guideway 16 into the card-reader 17. Operation of the timer 25 to run for this period is started, as referred to above, by the output signal from the gating unit 20 immediately preceding admission of the card to the guideway 16. If within this period there is no signal from the switch 41 (that is to say, if there is no signal to signify that the card has entered the card-reader 17), then the timer 25 supplies an output signal that has the effect of inhibiting further operation of the system. This output signal from the timer 25, as well as being supplied to the unit 22 to result in closure of the shutter 13, is supplied to disengage the clutch 24, and also to switch OFF the unit 23 and thereby break energization of the motor 26. The operation of the timer 25 to produce this output signal is inhibited however, when in the normal course of events there is actuation of the switch 41 before expiry of the pre-set period.

The signal supplied to the timer 25 and unit 22 upon actuation of the switch 41, is also supplied to disengage the clutch 24 and to engage a second clutch 42. Disengagement of the clutch 24 breaks drive from the motor 26 to the rollers 27 to 29, so that once the switch 41 is actuated drive to the card ceases. The card is restrained from movement in these circumstances by virtue of the pressure of the roller 29¹ holding it against the stationary roller 29.

Engagement of the second clutch 42 couples drive from the motor 26 to rotate two cams 43 and 44. Rotation of the cam 43 acts via a mechanical connection 45 to depress a stop 46 into the guideway 16 behind the roller 29¹, and following this to raise the roller 29¹ from the card. The raising of the roller 29¹ releases the pressure holding the card on the roller 29, and thereby allows the spring 40, acting via the plunger 39, to urge the card backwardly through the card-reader 17 until it abuts the depressed stop 46. Rotation of the cam 43 also acts via a mechanical connection 47 to lower the head 38 towards the bed 37. Final closure of the card-reader 17, with the card held firmly between the head 38 and bed 37, takes place with sufficient interval after the raising

of the roller 29¹ to allow the card to have moved backwardly to abut the stop 46. In this position the card is correctly located in the card-reader 17 for reading.

5 The cam 44, driven with the cam 43 through the clutch 42, rotates through an angular range of one-hundred-and-eighty degrees as the card-reader 17 is closed. Two electrical switches 48 and 49 are associated with the cam 44, the switch 48 to be actuated while the cam 44 is positioned at the beginning of this angular range, and the switch 49 to be actuated at the end of the range. Actuation of the switch 49 is indicative of the condition in which the card-reader 17 is fully closed, whereas actuation of the switch 48 is taken as being indicative of the condition in which the card-reader 17 is open. The switch 49 while actuated by the cam 44, supplies an electric signal to the clutch 42 and, via a lead 50, to a programming unit 51 (Figure 3). The application to the clutch 42 of the leading edge of this signal is effective to disengage the clutch 42 and thereby arrest further rotation of the cams 43 and 44. In the programming unit 51, the signal is effective to start operation of a timer (not shown), to cause illumination of a second sign (not shown) on the facia 10, and to provide a signal signifying that the card is in position in the card-reader 17, the existence of this latter signal being (as explained later) an essential for release of the dispenser to dispense a packet of bank-notes. The second sign on the facia 10 signifies ENTER PERSONAL-IDENTIFICATION NUMBER, and illumination of this directs the customer to enter his appropriate personal-identification number using a set of ten push-buttons 52 (only two of which are shown) mounted in four rows on the facia 10.

40 The personal-identification number is in each case a decimal number of six digits. The ten push-buttons 52 are accordingly numbered with the ten decimal digits 0 to 9 respectively, the six digits of the number being entered in order operating one push-button 52 at a time. The six-digit number entered in this way is compared in the system with the six-digit personal-identification number encoded on the card, the comparison process being carried out digit-by-digit. In this latter respect, however, the encoding of the personal-identification number on the card involves N decimal numbers, each of six digits (where N is an integer larger than unity). The sum of these N numbers taken without carry constitutes the relevant personal-identification number, (N-1) of these constituent numbers being chosen by a random selection process and the other being chosen to give the required sum.

60 The N constituent numbers are represented on the card in a binary-coded-decimal notation by the presence and absence of holes 3, the positions on the card accorded to the binary digits of the different N numbers being intermingled with one another according to a

predetermined pattern. This reduces the risk of the personal-identification number encoded on the card being deduced from the card alone or from comparison with other cards.

In the present system the personal-identification number is decoded from the card by an arithmetical operation which involves effectively the addition together of the N binary-coded decimal numbers taking one decimal place at a time and without effecting any carry from the relevant place to the next of higher significance. The values of the decimal digits of the N numbers are read from the card in binary-coded-decimal notation by the card-reader 17. The card-reader 17 when closed upon the card, automatically supplies signals on leads 53 in accordance with these values. The manner in which these signals are used in the system will now be described with reference to Figure 3.

Referring to Figure 3, the signals on the leads 53 from the card-reader 17 are applied to a selector unit 54. Each decimal digit read from the card is represented, according to the binary-coded-decimal notation, by the signals appearing on an individual group of four of the leads 53, there being in all 6N separate groups of four leads 53. The selector unit 54 is operated under the control of two sequencing units 55 and 56 to select the 6N groups of leads 53 in turn, and to apply the signals on the four leads 53 of the selected group to four output leads 57 respectively. The sequencing units 55 and 56 are each formed by bistable stages connected in cascade, the unit 55 having (N+1) stages I to (N+1), and the unit 56 seven stage I to VII. Each bistable stage has an ON, and an OFF, state, but at any one time only one stage in each unit 55 and 56 is in the ON state. Initially, before the customer depresses any of the push-buttons 52, it is the stage (N+1) of the unit 55, and the stage VII of the unit 56, that are in the ON state.

The ten push-buttons 52 marked 0 to 9, control via ten individual switches 58 the energization of ten input leads 59/0 to 59/9 respectively of a coding matrix 60. Depression of any one of the push-buttons 52, with the consequent actuation of the associated switch 58, energizes the appropriate one of the leads 59/0 to 59/9 to signal to the matrix 60 the value of the decimal digit entered by the customer. The coding matrix 60 in response to this supplies to four output leads 61 pulse signals that together signify the value of this digit according to binary-coded-decimal notation. The matrix 60 in each case also supplies to a fifth output lead 62, and thence to the programming unit 51, a pulse signal signifying that a digit has been entered. The programming unit 51 is responsive to this latter pulse signal in the presence of the signal on the lead 50, to supply a triggering pulse via leads 63 and 64 to the units 55 and 56 respectively.

When, therefore, the customer responds to the illuminated sign ENTER PERSONAL-IDENTIFICATION NUMBER, by depressing the push-button 52 appropriate to the first digit of his personal-identification number, pulse signals signifying the value of this digit appear on the output leads 61 of the matrix 60. These pulse signals are applied from the leads 61 to a register 65 to effect therein temporary storage of the relevant value in binary-coded-decimal notation. The pulse signal that also appears on the output lead 62 of the matrix 60, on the other hand, results in the application of a triggering pulse to the sequencing units 55 and 56 via the leads 63 and 64. Each unit 55 and 56 is responsive to this first triggering pulse to adopt the condition in which its stage I is in the ON state and all its other stages are in the OFF state. In these circumstances, signals representative of the first digit of a first of the N constituent numbers that are read from the card in the card-reader 17, appear on the output leads 57 of the selector unit 54. These signals are applied to a register 66 to effect therein temporary storage of the relevant value in binary-coded-decimal notation.

The register 66 receives via a lead 67 a train of regularly-recurring pulses supplied from the programming unit 51, and these pulses are used therein to count down to zero the value stored. Until the content of the register 66 reaches zero, the pulses supplied via the lead 67 are gated from the register 66 to a lead 68. The pulses appearing on the lead 68 are accordingly in number equal to the first decimal digit of the first constituent number read from the card. These pulses are passed via the lead 68 to the register 65 where they each reduce by unity the content of the register 65. Thus in the register 65 there is subtracted from the value of the first decimal digit entered by the customer, the value (stored by the register 66) of the first decimal digit of the first of the N constituent numbers that are read from the card. The subtraction process here is carried out as the equivalent of the addition to the content of the register 65 (in the scale of ten and without carry) of the tens-complement of the value stored by the register 66.

The programming unit 51, after it has supplied to the lead 67 a number of pulses sufficient to ensure positively that the register 66 has been counted down to zero (for example, after some sixteen pulses have been supplied), supplies another triggering pulse to the unit 55 (but not to the unit 56) via the lead 63. This triggering pulse switches stage I of the unit 55 to the OFF state and stage II to the ON state. In these circumstances signals that are representative of the value of the first digit of a second of the N constituent numbers read from the card, appear on the leads 57 to result in temporary storage of this value

in binary-coded-decimal notation, in the register 66. As before, pulses supplied to the register 66 via the lead 67 are gated to the lead 68 until the content of the register 66 is counted down to zero. The pulses gated to the lead 68, being in number equal to the value of the first digit of the second constituent number, effect the subtraction of this value from the content of the register 65.

The programming unit 51 again supplies a triggering pulse via the lead 63 to step the unit 55 on to the condition in which the next stage, stage III, is in the ON state. As a result, signals that are representative of the first digit of a third constituent number read from the card, appear on the lead 57 to effect temporary storage of this digit in the register 66. The pulses gated to the lead 68 in counting down to zero the content of the register 66, accordingly subtract the value of this digit from the content of the register 65.

The above process of subtracting the value of the first digit of a constituent number from the content of the register 65 is carried out in turn for all the N constituent numbers on the card, the stages I to N of the unit 55 being switched to the ON state successively. After the value of the first digit of the last, Nth, constituent number has been subtracted from the content of the register 65, the programming unit 51 again applies a triggering pulse to the unit 55 and this resets the unit 55 to its initial condition in which stage (N+1) is in the ON state. The switching of stage (N+1) to the ON state causes a pulse to be supplied from the unit 55 and via a lead 69 to a gate 70 associated with the register 65. The gate 70 is responsive to the state of the register 65, to pass this pulse on to a counter 71 only in the event that the value stored in the register 65 at this time is zero. Clearly, the number stored is zero only if the sum without carry, of the first digits of the N constituent numbers read from the card, is the same as the digit entered by the customer. There is no entry in the counter 71 in the event that this equality does not exist, since in these circumstances the value stored in the register 65 is not zero.

The pulse supplied from the unit 55 on the lead 69 is also supplied to the programming unit 51. The unit 51 is responsive to this pulse to apply to the register 65, via a lead 72 and after a short delay, a pulse signal clearing the register 65. This ensures that the content of the register 65 is positively returned to zero, in preparation for the entry by the customer of the next, second decimal digit of his personal-identification number.

When the customer depresses the push-button 52 appropriate to the second digit of his personal-identification number, the resultant pulse signals on the output leads 61 of the matrix 60 cause entry of the value of this digit into the register 65. In addition, the resultant

pulse signal on the lead 62 gives rise to a triggering pulse on both leads 63 and 64. The unit 55 is as a result set to the condition in which its stage I is in the ON state, whereas it is the stage II in the unit 56 that is now set to this state. In these circumstances the signals appearing on the leads 57 are representative of the second decimal digit of the first constituent number read from the card. The value of this digit as temporarily stored and counted down in the register 66, is (by means of the pulses gated to the lead 68) subtracted from the value of digit stored by the register 65. Following this, the programming unit 51 supplies a triggering pulse via the lead 63 to set the unit 55 to the condition in which its stage II is in the ON state, and the value of the second decimal digit of the second constituent number is then, in its turn, subtracted from the content of the register 65. This process is repeated, with the stages III to N of the unit 55 being brought successively to the ON state, to subtract in turn from the content of the register 65 the values of the second digits of the N constituent numbers. The subsequent switching of the stage (N+1) to the ON state in the unit 55, results in a pulse on the lead 69 and this, as before, is passed via the gate 70 to the counter 71 only if the content of the register 65 is then zero. The pulse on the lead 69 also, as before, results in the application to the register 65 via the lead 72 of a clearing signal in preparation for the entry by the customer of the third digit of his personal-identification number.

The operation of the system in response to the entry of the third digit of the personal-identification number and then, in turn, of the fourth to sixth digits, is substantially the same as described above. Upon entry of the relevant digit the unit 55 is reset to the condition in which its stage I is in the ON state, whereas the unit 56 is stepped on to the condition in which the next of its six stages I to VI is in this state. Thus, in response to entry of the fourth to sixth digits in turn, the unit 56 is set successively to select for reading out into the register 66 the values of the digits in the fourth to sixth digital places respectively of the N constituent numbers encoded on the card. While the unit 56 is set to select for reading out the values of the digits in any one of these digital places, the unit 55 is stepped on through the N states in which its stages I to N are successively in the ON state. The values of the digits in the relevant digital place in the N constituent numbers are therefore read out successively into the register 66, and are accordingly subtracted from the content of the register 65. After subtraction of these N values, a pulse on the lead 69 is gated to the counter 71 by the gate 70 only if the content of the register 65 is then zero.

When a pulse appears on the lead 69 following entry of the sixth digit of the personal-

identification number, the programming unit 51 supplies to the lead 64 a triggering pulse to switch the stage VII of the unit 56 to the ON state. This switching to the ON state of the stage VII causes a pulse to be supplied via a lead 73 to a gate 74 associated with the counter 71. The gate 74 is responsive to the count of the counter 71 to pass this pulse on to a dispenser-interlock unit 75 only in the event that the count is six. Clearly, the count is six only if the six-digit personal-identification number entered by the customer using the push-buttons 52, is identical to the six-digit personal-identification number encoded on the card in the card-reader 17.

The dispenser-interlock unit 75 is operable to supply energization current via a lead 77 to the dispenser 76, so as thereby to release the dispenser 76 to dispense one packet of bank-notes, in response to the pulse passed to the unit 75 by the gate 74. The operation of the unit 75 in this respect is however inhibited while signals are absent from either or both of leads 34 and 78 connected to the unit 75. The lead 34 is the output lead of the code-recognition unit 33 (Figure 2), and a signal appears on this lead 34 only if the card passed into the card-reader 17 has the magnetic-recordings appropriate to an authentic card. A signal is supplied from the programming unit 51 to the lead 78, on the other hand, only while there is a signal on the lead 50, that is to say, only while the card-reader 17 is closed upon a card. Thus it is only if the following three conditions are all satisfied that the dispenser 76 is released: the card has the magnetic-recordings appropriate to an authentic card; the card-reader 17 is closed upon a card; and the personal-identification number entered manually by the customer is the same as the personal-identification number encoded on the card.

A gate 79 is responsive to the circumstances in which energization current is not supplied to the lead 77 following the pulse on the lead 73, so as to provide a signal on a lead 80 signifying that the three essential conditions have not all been satisfied. The programming unit 51 is responsive to the pulse on the lead 80 to illustrate a third sign (not shown) on the facia 10 (Figure 2), this sign when illuminated directing the customer to enter again his personal-identification number (although of course the signal on the lead 80 may arise from a cause other than difference between the number entered manually and the personal-identification number encoded on the card). At the same time the programming unit 51 clears the counter 71 to restore the system to the condition existing just prior to the manual entry by the customer of his personal-identification number. (The connections required within the system for initial clearing purposes are not shown in the drawings in the interests of clarity). The system operates in

exactly the same manner in response to the second entry of the personal-identification number by the customer, as to the first entry. If as a result of the second entry, the three essential conditions at the unit 75 are still not satisfied, the dispenser 76 is again not released and the customer is again directed to enter his personal-identification number. Satisfaction of the three essential conditions at the unit 75 after either the second or third entry, results in release of the dispenser 76 in the manner described above in relation to the first entry. However, if after the third entry the three conditions are still not all satisfied, the transaction is treated as invalid; the unit 51 responding to three successive pulses on the lead 80 to illuminate a fourth sign (not shown) on the facia 10 (Figure 2) instead of said third sign. The fourth sign when illuminated indicates to the customer that the transaction is void and that his account will not be debited.

The programming unit 51 is responsive to the circumstances in which either energization current is supplied to the lead 77, or three successive pulses are received on the lead 80, to supply a signal via a lead 81 to reverse the motor 26 and re-engage the clutch 42 (Figure 2). This signal is applied to the lead 81 by the programming unit 51, and said fourth sign is illuminated, also in the event that the pre-set period of the timer (referred to above) in the unit 51 expires. This latter timer is set in operation by the leading edge of the signal applied to the lead 50, and is pre-set to run for a period adequate to enable manual entry of the personal-identification number three times under direction of the system. The appearance of energization current on the lead 77, or of three successive pulses on the lead 80, before expiry of the pre-set period, automatically terminates operation of this timer.

Referring again to Figure 2, the application to the lead 81 of the signal that reverses the motor 26 and re-engages the clutch 42, results in drive to the cams 43 and 44 rotating them back to their original angular positions. Accordingly, the roller 29¹ is lowered to hold the card against the stationary roller 29, and the stop 46 is then raised. The head 38 is raised so as to open the card-reader 17, and the switch 48, instead of the switch 49, is actuated. Actuation of the switch 48 results in the supply of a pulse signal to disengage the clutch 42. This signal is also applied to a timer unit 82 that in response thereto re-engages the clutch 24 for a pre-set period only. Re-engagement of the clutch 24 couples the rollers 27 to 29 to the reversed motor 26 so that these are now rotated in their reverse senses opposite to the arrows F. The card between the rollers 29 and 29¹ is accordingly withdrawn completely from the card-reader 17. During withdrawal the card is deflected by the spring 35 downwardly through the opening 36 to fall into a

suitably-placed bin (not shown) so as to be retained within the system. The card is ultimately retrieved from the system by bank staff both for accounting purposes and re-issue to the appropriate customer. In those circumstances where a packet of bank-notes is not dispensed, that is to say, those circumstances in which for any reason three successive pulses are supplied to the unit 51 via the lead 80 (Figure 3), or the pre-set period of the timer in the unit 51 runs out, the card is marked to signify this as it is being, or is about to be, withdrawn from the card-reader 17. To this end, an electromagnetically-operated punch (not shown) may be arranged to be energized from the programming unit 51 in either of these circumstances, the punch being located adjacent the stop 46 so as to punch a hole or notch in the card just prior to withdrawal.

When the pre-set period of the timer 82 runs out, a signal to this effect is passed from the timer 82 to the programming unit 51 via a lead 83. The unit 51 in response to this signal acts to prepare the system as whole (for example, by switching OFF the unit 23 and resetting the unit 33) for reception of another card at the mouth 11.

Provision may be made with the system for storing the personal-identification numbers of the individual cards already presented. In these circumstances, as each new card is presented a search of the stored numbers may be made to discover whether the personal-identification number encoded on the newly-presented card is already stored. Provision may then be made to allow the release of the dispenser only in the event that the number encoded on the card is not already stored more than, say, twice.

Additionally, the signals derived in the system may be used in the provision of automatic accounting and like processes in banking and commerce.

With the form of customer's card described above with reference to Figure 1, the pulse-recordings carried by the high-coercivity magnetic oxide of the coating 2 are masked by 'noise' recorded in the low-coercivity magnetic oxide. Although the use of magnetic-masking in this way provides an element of security it is certainly not an essential. In this latter respect, the coating 2 of the customer's card may consist of high-coercivity magnetic oxide alone, the pulse-recordings being recorded in this material and being read by the head 31 in checking the authenticity of the card, as before. Although no masking is used in these circumstances, the magnetic-recording head 30 is preferably retained and energized with alternating current as before, since this ensures that a card cannot satisfy the authenticity-check unless it carries magnetic material of sufficiently high coercivity. This applies whether or not the magnetic material on the card carries pulse recordings that would otherwise satisfy the

check, since the action of the head 30 is to erase any recorded signal from material having a coercivity less than the predetermined high value.

5 The system described in the present specification is the same as that described in the Complete Specification of co-pending Patent Application No. 10003/68 (Serial No. 1223557). Attention is also directed to co-
10 pending Patent Application No. 10536/67 (Serial No. 1223555) which is in the name of the present Applicants and others, and which includes description of the same system as described in the present application.

15 WHAT WE CLAIM IS:—

1. Access-control equipment for selectively enabling access to a facility, comprising first means for receiving a coded token presented to the equipment and for reading from the
20 received token a plurality of numbers encoded thereon, second means for entering into the equipment a further number, third means that is selectively operable for enabling access to said facility, and fourth means that is arranged
25 effectively to compare with the said further number the numerical result of a predetermined arithmetical operation that involves interaction upon one another of said numbers read from the token, said fourth means being
30 arranged to operate said third means as aforesaid in dependence upon whether a predetermined correspondence exists between said numerical result and said further number.

2. Access-control equipment according to
35 Claim 1 wherein said arithmetical operation involves summation of the numbers read from the token.

3. Access-control equipment according to
40 Claim 2 wherein said arithmetical operation is summation-without-carry of the numbers read from the token.

4. Access-control equipment according to
45 Claim 2 or Claim 3 wherein said fourth means is arranged to operate said third means to enable access to said facility only in the event that said further number is the same as the numerical result of said summation.

5. Access-control equipment according to
50 Claim 4 wherein said fourth means is arranged to effect comparison of said numerical result with said further number by subtraction of one from the other, and is arranged to operate said third means only in the event that the result of the subtraction process is zero.

6. Access-control equipment according to
55 Claim 2 wherein said first means is arranged to read from the coded token plural-digit numbers encoded thereon, said second means is means for entering a plural-digit number
60 into the equipment, and said fourth means is arranged effectively to compare digit-by-digit the numerical result of summation-without-carry of the numbers read from the token, with said plural-digit number entered by said second means.
65

7. Access-control equipment according to Claim 6 including means for reading from the coded token N decimal numbers each of M digits, where M and N, which may be equal, are both integers greater than unity, means for entering into the equipment an M-digit decimal number one digit at a time in ordered sequence, means arranged to perform in respect of each of the M entered-digits a subtraction process in which there is subtracted from the value of the relevant entered-digit the values of N decimal digits that in the N decimal numbers respectively occupy one and the same digital place, the particular one of the digital places concerned being dependent upon the order in said sequence of the entered-digit, and means for operating said third means only in the event that the result of each of the M subtraction processes is zero.

8. Access-control equipment according to any one of Claims 1 to 7 wherein said second means includes manually-operable means for entering the said further number into the equipment, the particular number entered being dependent upon manual selection.

9. Access-control equipment according to Claim 8 wherein said manually-operable means includes a set of ten manually-operable keys that are operable selectively to enter into the equipment decimal digits 0 to 9 respectively.

10. Access-control equipment according to any one of Claims 1 to 9 including means for detecting whether the received token has a predetermined characteristic, said predetermined characteristics being a characteristic indicative, at least partly, of authenticity of the token, and the arrangement being such that operation of said third means is inhibited in the event that said predetermined characteristic is not detected.

11. Access-control equipment according to Claim 10 wherein said predetermined characteristic is a magnetic characteristic.

12. Access-control equipment according to any one of Claims 1 to 9 including erasure means for submitting the received token to a magnetic erasure process, the erasure process erasing magnetic recording from any magnetic material having less than a predetermined coercivity submitted to that process, and detecting means for detecting magnetic recording remaining on the token after the token has been submitted to the erasure process, the arrangement being such that operation of said third means is inhibited in the event that a magnetic recording is not detected by said detecting means.

13. Access-control equipment according to Claim 12 including means arranged to read magnetic pulse-recordings from the received token, and means for providing a count of the pulses read from the token, the arrangement being such that operation of said third means is inhibited in the event that said count differs

check, since the action of the head 30 is to erase any recorded signal from material having a coercivity less than the predetermined high value.

The system described in the present specification is the same as that described in the Complete Specification of co-pending Patent Application No. 10003/68 (Serial No. 1223557). Attention is also directed to co-pending Patent Application No. 10536/67 (Serial No. 1223555) which is in the name of the present Applicants and others, and which includes description of the same system as described in the present application.

WHAT WE CLAIM IS:—

1. Access-control equipment for selectively enabling access to a facility, comprising first means for receiving a coded token presented to the equipment and for reading from the received token a plurality of numbers encoded thereon, second means for entering into the equipment a further number, third means that is selectively operable for enabling access to said facility, and fourth means that is arranged effectively to compare with the said further number the numerical result of a predetermined arithmetical operation that involves interaction upon one another of said numbers read from the token, said fourth means being arranged to operate said third means as aforesaid in dependence upon whether a predetermined correspondence exists between said numerical result and said further number.

2. Access-control equipment according to Claim 1 wherein said arithmetical operation involves summation of the numbers read from the token.

3. Access-control equipment according to Claim 2 wherein said arithmetical operation is summation-without-carry of the numbers read from the token.

4. Access-control equipment according to Claim 2 or Claim 3 wherein said fourth means is arranged to operate said third means to enable access to said facility only in the event that said further number is the same as the numerical result of said summation.

5. Access-control equipment according to Claim 4 wherein said fourth means is arranged to effect comparison of said numerical result with said further number by subtraction of one from the other, and is arranged to operate said third means only in the event that the result of the subtraction process is zero.

6. Access-control equipment according to Claim 2 wherein said first means is arranged to read from the coded token plural-digit numbers encoded thereon, said second means is means for entering a plural-digit number into the equipment, and said fourth means is arranged effectively to compare digit-by-digit the numerical result of summation-without-carry of the numbers read from the token, with said plural-digit number entered by said second means.

7. Access-control equipment according to Claim 6 including means for reading from the coded token N decimal numbers each of M digits, where M and N, which may be equal, are both integers greater than unity, means for entering into the equipment an M-digit decimal number one digit at a time in ordered sequence, means arranged to perform in respect of each of the M entered-digits a subtraction process in which there is subtracted from the value of the relevant entered-digit the values of N decimal digits that in the N decimal numbers respectively occupy one and the same digital place, the particular one of the digital places concerned being dependent upon the order in said sequence of the entered-digit, and means for operating said third means only in the event that the result of each of the M subtraction processes is zero.

8. Access-control equipment according to any one of Claims 1 to 7 wherein said second means includes manually-operable means for entering the said further number into the equipment, the particular number entered being dependent upon manual selection.

9. Access-control equipment according to Claim 8 wherein said manually-operable means includes a set of ten manually-operable keys that are operable selectively to enter into the equipment decimal digits 0 to 9 respectively.

10. Access-control equipment according to any one of Claims 1 to 9 including means for detecting whether the received token has a predetermined characteristic, said predetermined characteristics being a characteristic indicative, at least partly, of authenticity of the token, and the arrangement being such that operation of said third means is inhibited in the event that said predetermined characteristic is not detected.

11. Access-control equipment according to Claim 10 wherein said predetermined characteristic is a magnetic characteristic.

12. Access-control equipment according to any one of Claims 1 to 9 including erasure means for submitting the received token to a magnetic erasure process, the erasure process erasing magnetic recording from any magnetic material having less than a predetermined coercivity submitted to that process, and detecting means for detecting magnetic recording remaining on the token after the token has been submitted to the erasure process, the arrangement being such that operation of said third means is inhibited in the event that a magnetic recording is not detected by said detecting means.

13. Access-control equipment according to Claim 12 including means arranged to read magnetic pulse-recordings from the received token, and means for providing a count of the pulses read from the token, the arrangement being such that operation of said third means is inhibited in the event that said count differs



from a predetermined number.

14. Access-control equipment according to any one of Claims 1 to 13 wherein said first means includes token-entry means providing an entrance to the equipment for a coded token, token-reading means spaced from said entrance, and a token-transport arrangement for transporting to said token-reading means a token admitted to the equipment through said entrance, said token-reading means being arranged to read from the token transported thereto by said token-transport arrangement a plurality of numbers encoded on the token.

15. Access-control equipment according to Claim 14 wherein said token-entry means includes a shutter device for blocking entry through said entrance of a token presented to the equipment, means for detecting whether a token presented to the equipment at said entrance has a predetermined characteristic, and means for displacing said shutter device to admit the token through said entrance only in the event that this predetermined characteristic is detected.

16. An item-dispensing system comprising means for receiving a coded token presented to the system and for reading from the received token a plurality of plural-digit numbers encoded thereon, means which is operable manually for entering into the system a further plural-digit number, the particular number entered being dependent upon manual selection, item-dispensing means which is selectively operable to dispense from a reserve of items at least one such item upon each operation of the item-dispensing means, and comparison means arranged effectively to compare with the said further number the numerical result of a predetermined arithmetical operation that involves interaction upon one another of said plural-digit numbers read from the token, said comparison means being arranged to operate said item-dispensing means to dispense at least one of said items as aforesaid in dependence upon whether a predetermined correspondence exists between said numerical result and said further number.

17. An item-dispensing system according to Claim 16 wherein said arithmetical operation is summation of the numbers read from the token.

18. An item-dispensing system according to Claim 17 wherein said comparison means is arranged effectively to compare digit-by-digit the numerical result of summation-without-carry of the numbers read from the token, with the manually-entered number.

19. An item-dispensing system according to Claim 18 including token-reading means for reading from the coded token N decimal numbers each of M digits, where M and N,

which may be equal, are both integers greater than unity, said manually-operable means being means for entering into the equipment an M-digit decimal number one digit at a time in ordered sequence, means arranged to perform in respect of each of the M entered-digits a subtraction process in which there is subtracted from the value of the relevant entered-digit the values of N decimal digits that in the N decimal numbers respectively occupy one and the same digital place, the particular one of the digital places concerned being dependent upon the order in said sequence of the entered-digit, and means for operating said item-dispensing means only in the event that the result of each of the M subtraction processes is zero.

20. An item-dispensing system according to Claim 19 including token-entry means providing an entrance to the system for a coded token, said token-reading means being spaced from said entrance, a token-transport arrangement for transporting along a path to said token-reading means a token admitted to the system through said entrance.

21. An item-dispensing system according to Claim 20 wherein said token-entry means includes a shutter device for blocking entry through said entrance of a token presented to the system, means for detecting whether a token presented to the system at said entrance has a predetermined characteristic, and means for displacing said shutter device to admit the token through said entrance only in the event that the predetermined characteristic is detected.

22. An item-dispensing system according to Claim 20 or Claim 21 including a magnetic reading head positioned along said path for detecting magnetic recording on the token, the arrangement being such that operation of said item-dispensing means is inhibited in the event that magnetic recording is not detected by the reading head.

23. An item-dispensing system according to Claim 22 including a device positioned along said path at a point in advance of the reading head, for erasing magnetic recording from magnetic material having less than a predetermined coercivity passing that point.

24. An item-dispensing system according to any one of Claims 16 to 23 wherein said manually-operable means includes a set of ten manually-operable keys that are operable selectively to enter into the system decimal digits 0 to 9 respectively.

25. An item-dispensing system substantially as hereinbefore described with reference to the drawings accompanying the Provisional Specification.



26. In a bank, an item-dispensing system according to any one of Claims 16 to 25, for dispensing packets of money.

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