April 27, 1965 J. LÖSCH ETAL 3,181,121

ELECTRONIC PROGRAMME-CONTROL

Filed Nov. 25, 1958 3 Sheets-Sheet 1

Fig.1

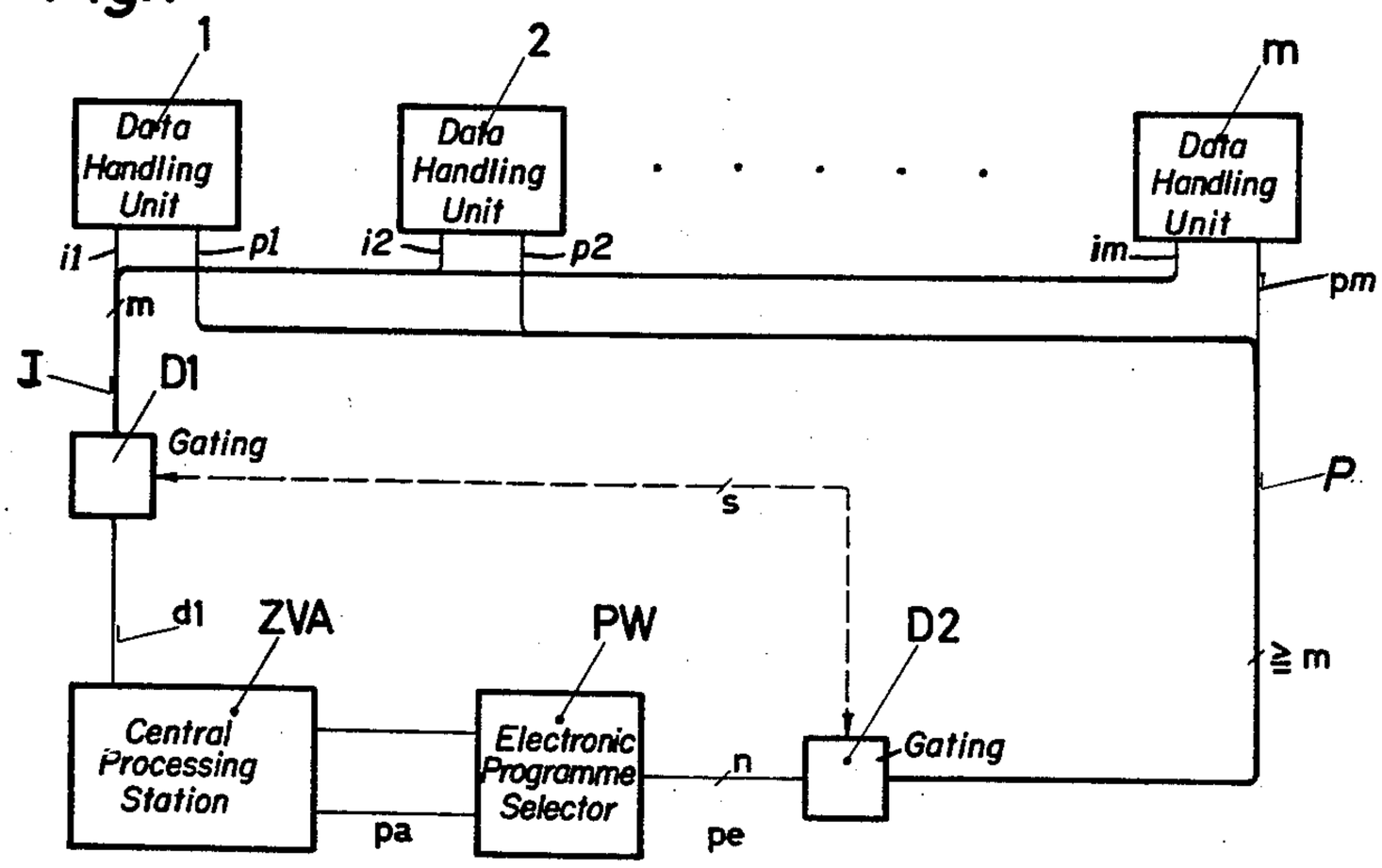
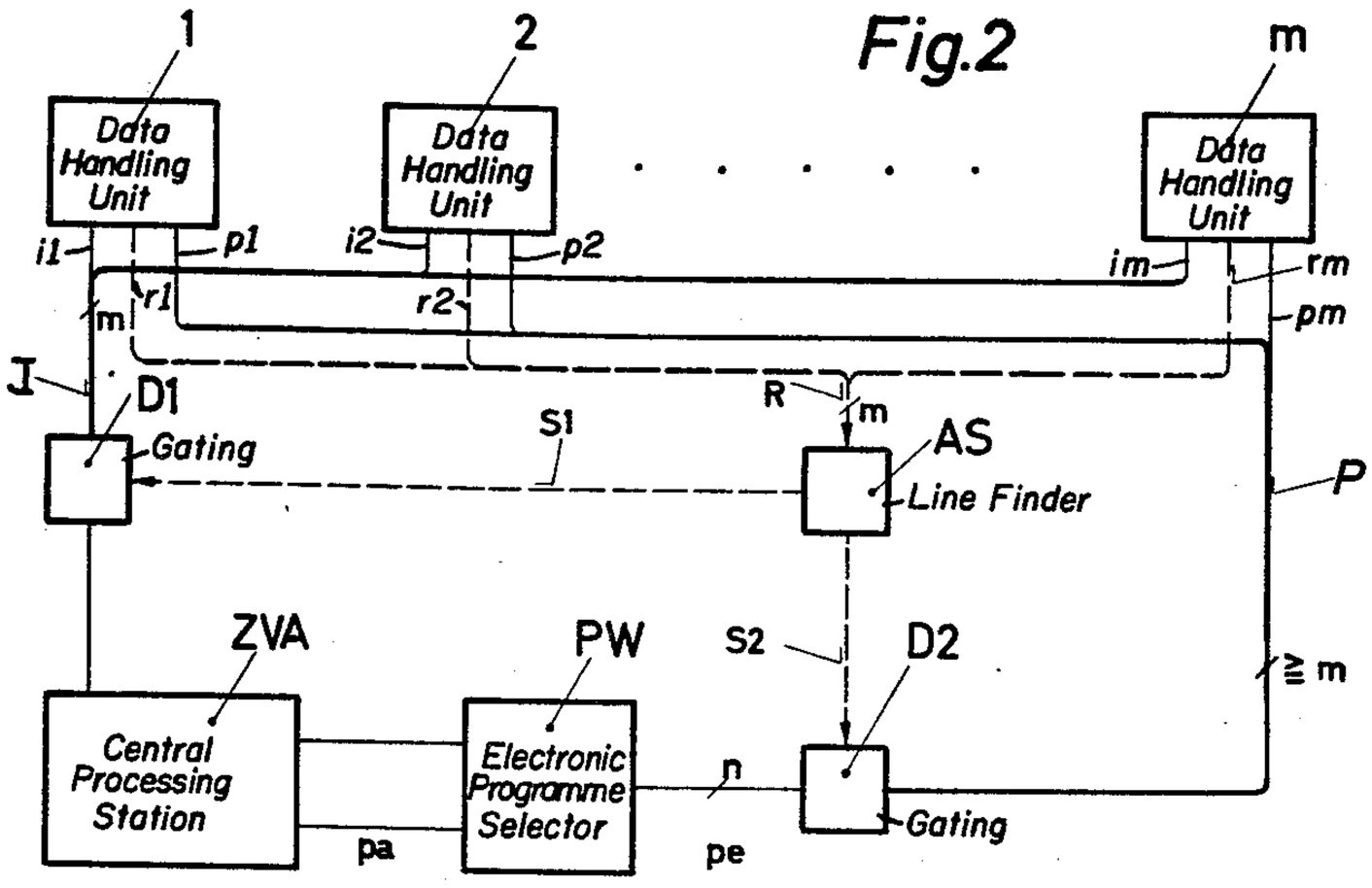


Fig.2



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ELECTRONIC PROGRAMME-CONTROL

Filed Nov. 25, 1958 3 Sheets-Sheet 2

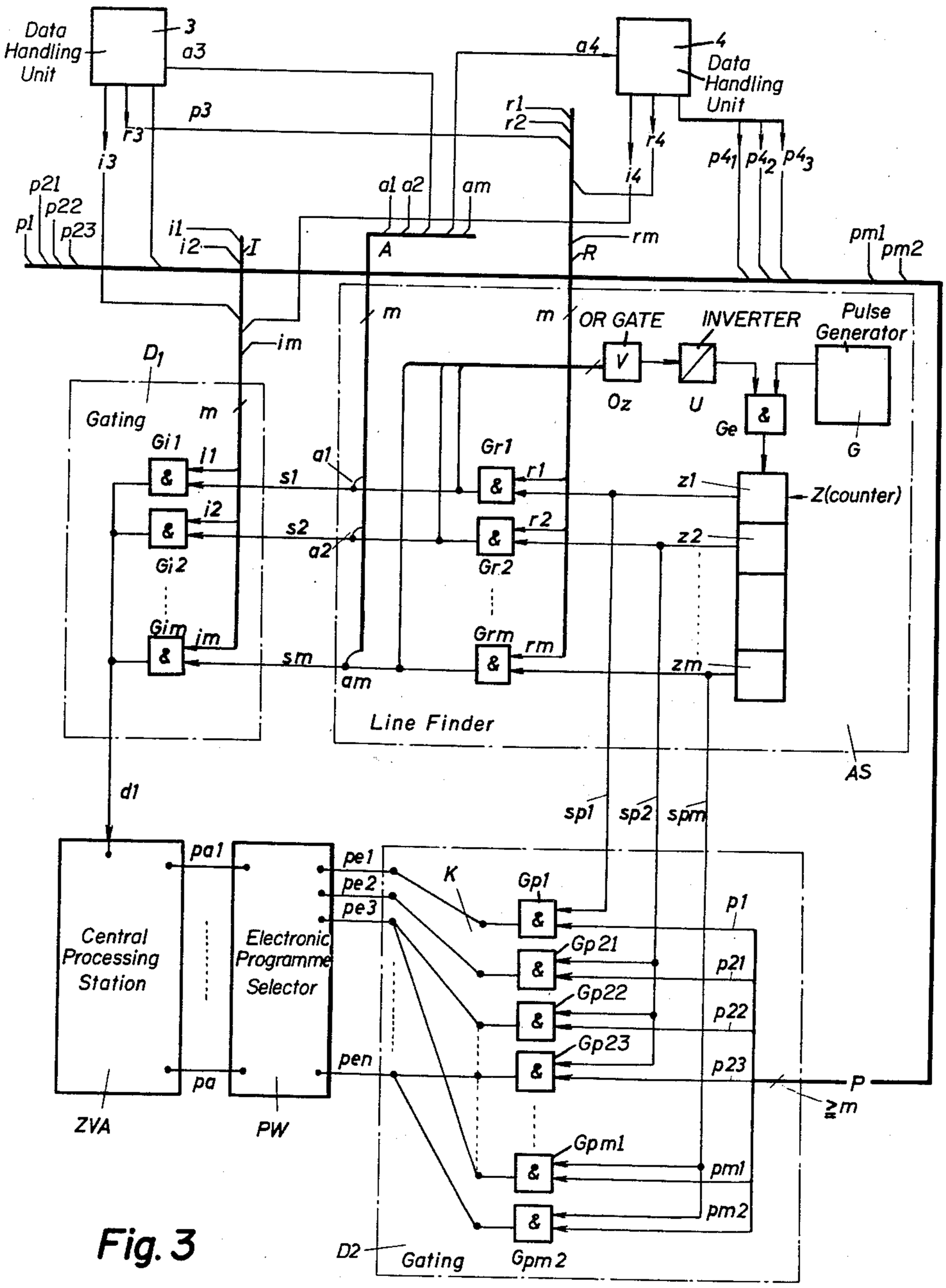

Fig. 3

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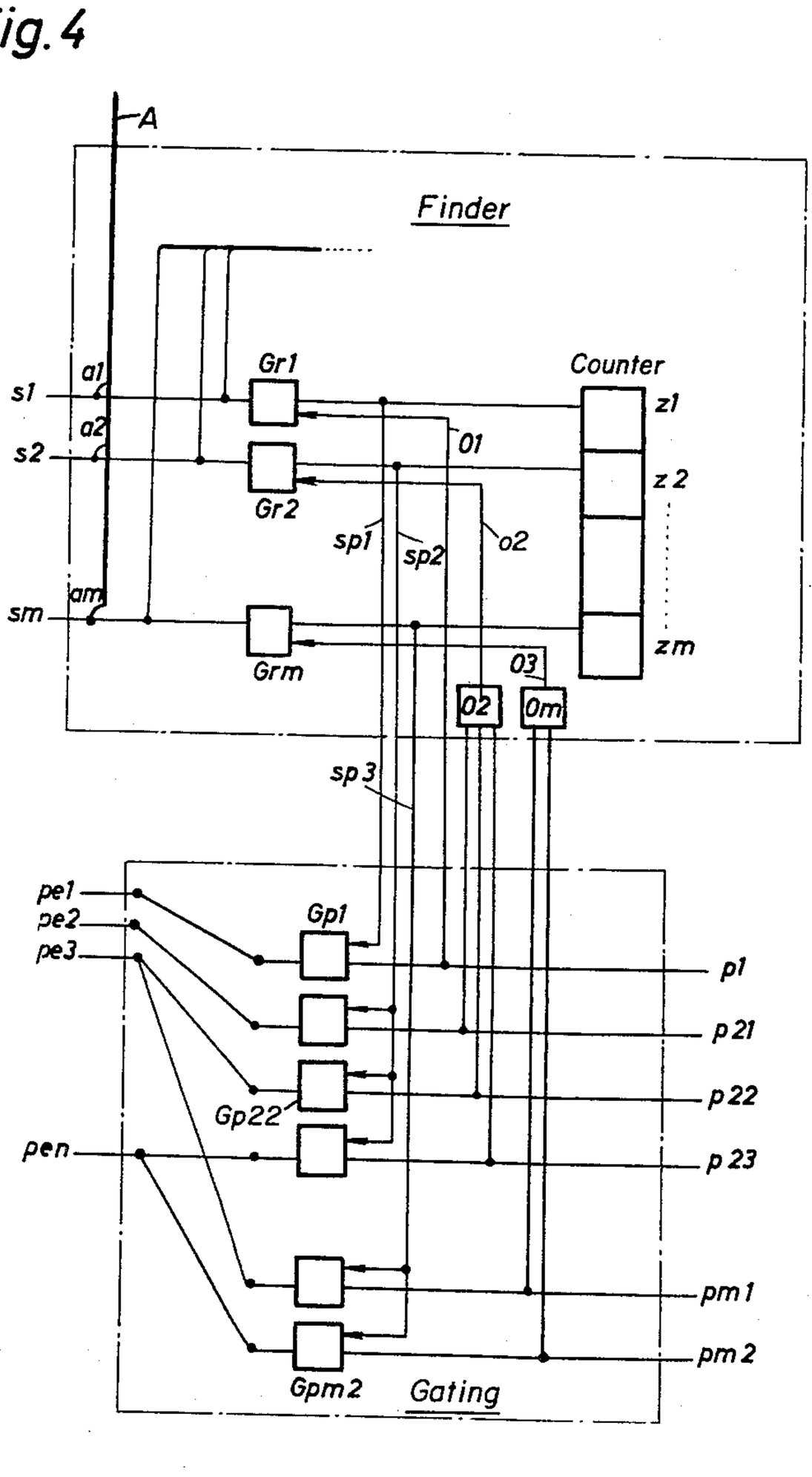
ELECTRONIC PROGRAMME-CONTROL

Filed Nov. 25, 1958 3 Sheets-Sheet 3

Fig. 4



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ELECTRONIC PROGRAMME-CONTROL

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Claims priority, application Germany, Dec. 12, 1957, 13,250/57
9 Claims. (Cl. 340—147)

This invention relates to an electronic programme-control for data-processing systems comprising a central processing-station, such as an electronic computing, booking- or sorting-unit, to which several input- and output-units are connected. In such kinds of systems the central processing-station generally consists of a number of structural units which are more or less independent, such as storages, highspeed storages, computing- sorting-stages, and the like, which are connected together or in individual groups for accomplishing different results.

In conventional types of electronic computing and booking systems, pluggable programmes may be provided, permitting certain programmes to be plugged in for carrying out specific sequences of operations. Thus, with respect to the stock-on-hand supervision the recording of received goods is of interest on the one hand, and, on the other hand, the recording of the stock-on-hand at certain times. In accordance with the present state of the art and for carrying out these and other operations, a computing system is set manually for a certain time to the programme "recording of received goods" or to the programme "recording of outgoing goods," or to the programme of "printing issue vouchers," and a greater number of operations are processed for whichever programme the system is set. In accordance with another conventional solution, provision is made to produce first of all from each process record means, preferably punched cards or perforated tapes, on which the respectively desired processing-programme is characterized by control marks, which record means are then processed in accordance with the programme, as indicated by the control marks. In either case, and on account of manually released programme controls, or by the time required for producing the record means, time delays appear between the availability of the information and its processing, and it is impossible to immediately process the informations directly upon receipt and in the order of succession of the reception.

In order to avoid frequent and time-wasting changes of the programme, certain operating conditions have to be adhered to in such a system, e.g. performance of recordings regarding outgoing goods during the normal business-hours, and the performance of stock-keeping corrections by recording the incoming goods, as well as the listing-out of the stock figures outside the regular working time.

From the above described example it will be seen that in systems with fixed programmes, a really economical utilization of the equipment can only be accomplished when the same programmes can be maintained throughout longer periods of time.

With respect to computing systems, the conditions differ in so far as frequent changes of the programme are necessary. For this reason, in high-speed computing systems, instead of a control of the programme by means of pluggable programmes, a controlling by means of individual orders or instructions, or successions thereof has been provided. In this case the individual information which is supposed to be processed within one operating cycle of the machine is preceded by an instruction which is either fed in together with this information, or is being called up on account of an instruction number from a

special instruction storage device (programme storage). Such an instruction-controlled programme is suitable above all whenever long-lasting computing operations, for instance, scientific calculations are concerned. In this case a plurality of computing operations has to be repeated in a routine manner in the order of sequence, as given by the list of instructions, and the majority of the intermediate results is further processed within the machine itself, whereas only a small portion of the obtained results is fed out via a list-printer or any other output-unit at the end of the computing programme. For this reason also the number of input- and output-units which are provided in electronic computers, is relatively small.

The present invention is based on the problem of providing, for data-processing systems employing a high-speed electronic processing unit, an automatic programme-control permitting a cooperation of this central processing station with a plurality of more or less slow-operating input- and output-units of different types, even in the case of a frequent change in programme corresponding to the the different types of units.

The object of the present invention is to provide an electronic programme-control for use in data-processing systems employing a central processing station and a plurality of different input- and output-units capable of being connected with this central station via gating means and corresponding information-transmission leads, in particular for employment with computing-, reading- and booking-systems.

According to the invention this electronic programme-control of data-processing systems is arranged in such way that control leads are assigned to each input- and output-unit indicating to the central processing station, by means of marking potentials, the respectively required programme, as well as the state of being ready for operation of the respective unit, and so that the marking potentials are only applied to an electronic programme-selector after the information or control leads have been connected through to the central processing station, and so that, via this electronic programme-selector, the central processing station is switched over to the indicated programme by the action of electronically controlled switches. Preferably a special call line is assigned to each respective input- or output-unit for indicating the ready-to-operate condition, as well as one or more programme control leads for selecting the programme, and furthermore the arrangement is made in such a way that the gating means are connected with a line finder which is adapted to effect a cyclical scanning of the call lines and which is rendered inoperative via the first call line conducting a marking potential, until the programme corresponding to this call line and the control line which is assigned thereto is called up in the central processing station. In a variation, the special call or unit ready lines can be omitted and their function usurped by the programme call lines.

The automatic programme-control, according to the invention, has the great advantage that, in cases where a high-speed electronic processing unit cooperates with a plurality of input- and output-units of the same or of a different type, which are actually mostly rather slow with respect to their operation, due to their mechanical or electromechanical component parts, and, accordingly, with the same or different information processing programmes, complete utilization of the operating capacity of the central processing station is obtained. In the following, further advantages and features of the invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 shows an elemental block diagram for the system involving an electronic programme-control,

FIG. 2 shows a block diagram of the system embracing the main or preferred embodiment of the invention involving control of the gating means and the electronic programme-selector via unit-ready lines, programme call lines and line finder,

FIG. 3 shows a basic circuit diagram for the line finders and the gating means for information-transmission- and control leads in their preferred arrangement schematically indicated in FIG. 2, and

FIG. 4 shows a basic circuit diagram relating to the variation in which the function of the unit-ready lines in controlling the line finder is usurped by the programme call or control leads.

In FIG. 1 there is shown a block diagram for data-processing systems employing an electronic programme-control. The central data processing station ZVA and *m* data handling units; that is respective data input- or output-units 1, 2, . . ., *m*, are connected with each other on the one hand, via information-transmission lines *i* and, on the other hand, via programme call or control leads *p*. For reasons of simplicity, only one line *i* and one line *p* have been shown in FIG. 1 for each respective input- or output-unit. However, in the case of different types of input- and output-units several *i*- and *p*-lines per unit may also be provided. For reasons of clarity the *i*- and *p*-lines of all input- and output-units are shown assembled to form respectively a cable I and a cable P.

The cable I is terminated in a gating arrangement D1 selectively permitting the connection from any one of the *n* respective input- or output-units to the central processing station ZVA. The cable P is terminated in a gating arrangement D2, permitting the connection of one of the programme call or control leads *p* with one of the *n* input lines *pe*.

The input lines *pe* are connected with an electronic programme-selector PW and enable the selection of *n* different programmes. Via the output lines *pa*, the electronic programme-selector is connected with the central processing station ZVA. Via these output lines, the electronic programme-selector controls the sequence of functions in the central processing station in accordance with the programme as selected by marking one of the *n* input lines.

For permitting the application of the marking potentials to the electronic programme-selector only after the information-transmission lines have been connected to the central processing station, the gating arrangements D1 and D2 are connected with each other via control leads S. As a rule the number of these control leads is at least equal to the number of respective input- or output-units, or respectively corresponds to the number of different types of these units.

In the above described elemental embodiment the programme-lines *p*, also referred to as programme call or programme control lines or leads, are adapted to perform two different functions. On the one hand, they indicate the ready-to-operate condition of the respective input- or output-units and, on the other hand, they are adapted to control the programme-selection. In order to simplify the circuit arrangement of the respective gating means D1 or D2, it is appropriate to separate these two functions and to provide special call lines for indicating the ready-to-operate condition. In FIG. 2 there is shown a corresponding block diagram of a system incorporating the main or preferred embodiment of the invention. In accordance with the showing of FIG. 2, one call line *r* is assigned to each of the *m* respective input- or output-units, which call line is indicated by a dashline. The call lines of all input- or output-units are shown assembled to form a cable R which is connected with a line finder AS. This line finder is adapted to control the gating means D1 and D2 via control leads S1 and S2, respectively.

Apparatus further exemplifying the main embodiment of the invention, diagrammed in FIG. 2, is shown in FIG. 3. This FIG. 3 shows a detailed basic circuit diagram relating to the gating arrangement D1 and D2, as well as the line finder AS. For making the construction of the gating arrangement D1 as simple as possible it has been assumed that only one information-transmission line has been assigned to each of the input- and output-units, on which line individual bits of binary-coded information are transmitted in series. It is to be understood, however, that the expression information transmission line (*i*) or the like is to have a broad connotation also covering a multi-wire channel for the concurrent transmission of item coding bits and that a single line and connected gate as shown may represent a multi-wire channel and corresponding multiple gating. Similar broad meaning is to be accorded the terms unit-ready or call line (*r*) and programme call line (*p*).

As shown in the FIG. 3 embodiment, the information-transmission line *i*3, as well as the call line *r*3 and the programme line *p*3 are assigned to the input-unit 3. The information-transmission line *i*4, the call line *r*4 as well as three programme lines $p4_1$, $p4_2$ and $p4_3$ are assigned to the input unit 4.

The differences relating to the different programmes which are capable of being selected via the programme lines $p4_1$ through $p4_3$ will be described hereinafter in connection with an example of practical application.

As will be seen from the showing of FIG. 3, the cable I is connected with the gating arrangement D1. The individual information-transmission lines *i*1–*im* are respectively applied to the associating gating circuits G*i*1 through G*im*, each information transmission line to one of the inputs of the associated gating circuit. The information input-gates are designed as AND-gates. The outputs of the information input-gates are connected with a bus bar *d*1 which is adapted to feed the information applied via any of the information input-gates to the central processing unit ZVA.

The call lines *r* of all data-handling input- and output-units are connected with the line finder AS. In this line finder one call gate G*r* is assigned to each of the call lines *r*. For instance, the call line *r*1 is connected with one input of the gate G*r*1, etc., and the call line *rm* with one input of the gate G*rm*. The call gates are likewise designed as AND-gates. The outputs thereof are connected respectively with the second inputs of the information input-gates G*i*1 through G*im* via the corresponding control leads *s*1 through *sm*.

For effecting the cyclical scanning of the ready-to-operate indication by the call lines a counter Z is provided in the line finder comprising a number of stages Z1, Z2 through Z*m* corresponding to the number of respective input- or output-units, the outputs of said counting stages being respectively connected with the second inputs of the corresponding call gates G*r*1 . . . G*rm*. The corresponding information-transmission path will only be connected from the respective input unit to the central processing station in the event of a coincidence of both the counter position and the ready-to-operate indication on the call line.

For example, if the call line *r*2 is marked or indexed with a call indicating potential, and if the counter assumes the position Z2, then the call gate G*r*2 will be opened and its output *s*2 will accordingly also be excited, thus unblocking the information input-gate G*i*2.

By this unblocking of the information input-gate G*i*2 the operating resistance which is connected to the information line *i*2 will be varied. This variation of the operating resistance may be utilized for reading the information from the input-unit 2. However, as shown in FIG. 3, there may also be provided an information-reading line *a*2 which is connected to the output of G*r*2, and which is furthermore connected with the associating input-unit 2. In FIG. 3, by way of example, the information-reading line *a*4 for the input-unit 4 is excited upon operation of the call gate G*r*4 (not shown) associated therewith to notify or condition this input-unit to read or apply in-

formation bits to the associated reading gate *Gi*. For simplifying the representation, the information-reading line *a*1 through *am* are shown to be gathered into one cable A.

Furthermore it is assumed that the input- or output-units are so designed that the marking of their call line will be disconnected after the respectively selected programme has been carried out. If so required, this disconnection may also be effected by the central processing station by means of indication "End of Programme" which is transmitted via a special line.

After the programme has been carried out with respect to one certain input- or output-unit the counter Z may be stepped on until it detects the next successive input- or output-unit which is ready to operate. To this end there is provided in the line finder AS a pulse-generator G which, via an AND-gate *Ge*, feeds stepping pulses to the counter Z whenever *Ge* is unblocked. The second input of *Ge* is indirectly controlled by the call lines *r*, that is, via the call gates and the control leads *s*1 through *sm*. These control leads are individually connected with the inputs of an OR-gate Oz which is unblocked when one of the control leads is energized. The output of the OR-gate Oz is connected via an inverter U with one input of *Ge*. In the conventional manner the inverter U operates in such a way that its output is energized whenever its input is not energized, and vice versa. By means of this, and as long as one of the control leads is energized, the input of U will be energized via Oz and, consequently, *Ge* will be blocked. Assuming, for instance, that the control lead *s*2 is energized so that correspondingly the input-unit 2 is connected and conditioned for transmission of data to the central processing station, then *Ge* is blocked and the counter is prevented from being stepped on until the programme which is desired by the input-unit 2 has been completely carried out.

After this programme has been carried out, the marking of the call line *r*2 will be discontinued and, consequently, *Gr*2 will be blocked, so that now the control lead *s*2 is no longer energized. As long as the counter Z still remains in the position Z2, also none of the other control leads can be energized. On account of none of the leads *s* being energized, the OR gate Oz will not be energized, the input of U will not be energized and, via the output of U, the gate *Ge* will be unblocked, so that now stepping pulses will be transmitted from the generator G to the counter Z, and the counter will be stepped on until, in the event of a coincidence of both the counter position and the marking of the matching call line *r*, a new control lead *s* will be energized. This control lead, being energized will then, in the manner described, suppress the further application of stepping pulses; hence the counter Z will stay in its new position until the marking potential on the matching call line *r* is removed.

The controlling of the line finder AS by the call lines *r* has been described above, as well as the cooperation of the line finder with the gating arrangement D1 for the transmission of information from the data handling units to the data processing means ZVA. In the following the connecting-through of the programme lines *p* within the gating arrangement D2 to the electronic programme selector PW will now be described. For the connecting-through of the programme lines *p*, a number of AND-gates *Gp*1 through *Gpm*2 is provided in the arrangement D2 corresponding to the number of programme lines. One input of each of these AND-gates is connected with the respective associated programme line. In FIG. 3 the programme lines *p*1, *p*21, *p*22, *p*23, . . . *pm*1, *pm*2 are shown conforming to the assumption that only one programme line is assigned to the input-unit 1, three programme lines to the input-unit 2, and two programme lines to the input-unit *m*.

The connection of the programme lines *p* to the input lines *pe* of the electronic programme-selector PW is effected by gates *Gp* under the control of the counter Z of the line finder AS. The outputs of the counter stages *z*1 through *zm* are connected via corresponding control leads *sp*1 through *spm* with the AND-gates in the arrangement D2. Since, as already mentioned in the foregoing, only one programme line *p*1 is provided for the input-unit 1, the control lead *sp*1 only leads to the gate *Gp*1. With respect to the input-unit 2, three programme lines *p*21 through *p*23 are provided, and, correspondingly, the control lead *sp*2 is connected with the inputs of the gates *Gp*21, *Gp*22 and *Gp*23.

Considering now the case again in which, by coincidence of both the counter position *z*2 and the marking of the call line *r*2, the control lead *s*2 is energized, by which a data transmitting connection from the input-unit 2 to the central processing station ZVA is effected. At the same time when the counter assumes the position *z*2, the control lead *sp*2 will be energized. This control lead in the arrangement D2 will condition the gates *Gp*21 through *Gp*23 for response to the energization or marking of programme call lines *p*21, *p*22 and *p*23 of the data handling unit 2. In the data handling input-unit 2, suppose that the programme line *p*22 has been marked. Thereupon, and via *Gp*22, in the example according to FIG. 3, the input line *pe*3 of the electronic programme-selector will be energized. By means of the line *pe*3 the programme with the number 3 will be selected.

The control leads *sp*1 through *spm* may also be connected to the control leads *s*1 through *sm* and not, as in the described example of embodiment, to the outputs *z*1 through *zm* of the counter. This bears the advantage that additional component parts—which are not shown in FIG. 3—for suppressing momentary markings of the input lines *pe* can be avoided.

The outputs of *Gp* gates may be variously wired to the input lines *pe*, as by plug wires K. As indicated in FIG. 3, the outputs of *Gp*22 and *Gpm*1 are both wired to input line *pe*3; hence the input line *pe*3 may also be selected by the input-unit *m* by marking the programme line *pm*1 via the gate *Gpm*1. Altogether it is assumed in the above mentioned example that the electronic programme-selector is designed for the selection of *n* different programmes. Accordingly, the gating arrangement D2 is provided with *n* outputs. The programme lines *p* are applied to the input side of D2, the number of lines being at least equal to the number of the input- and output-units. In most cases the number of programme lines *p* is substantially greater, because the input- and output-units respectively require several programmes.

It is still to be mentioned that in the gating arrangement D1, the gates *Gi*1, *Gi*2 and *Gim*, which are shown in FIG. 3, are indicated as information input-gates. Accordingly, the data handling units 1, 2, 3, 4 to *m* are input-units. Whenever the data handling units to be connected are output units, then the corresponding AND-gates in the arrangement D1 will have to be connected as information output-gates, in other words, in the reversed forward-direction. If input- or output-units are each to be connected with the central processing station by means of several information-transmission lines, then, for each of these lines as well as for every desired forward-direction (pass-direction), a corresponding AND-gate will have to be provided which is to be unblocked by the associating control lead *s* in dependence upon the position of the counter and the marking of the call lines *r*.

Up to now it has been presupposed that the indication as to the ready-to-operate state is effected via special call lines *r*. However, with respect to the case in which the programme lines *p* in both the input- and output-units are only marked when these units and already ready to operate, the controlling of the line finder may also be effected via the programme lines themselves. In FIG. 4 of the drawings there is shown a variation of the FIG. 3 embodiment of the invention. In this variation, the gates *Gr* of the line finder are controlled by the programme lines *p* as well as by the counter stages *z*1 to *zm*.

In the example shown in FIG. 4, programme line *p*1 (from input unit 1—FIG. 3) has a branch connection O1 to an input of the gate G*r*1, the three programme lines *p*21, *p*22 and *p*23 of the input-unit 2 are connected with the three inputs of the OR-gate O2, and the two programme lines *pm*1 and *pm*2 of the input-unit *m* connect with the two inputs of the OR-gate O*m*. The outputs of these OR-gates, in pairs with the outputs of the corresponding counting stages, constitute the inputs of the associated call gates G*r*2 and G*rm*. Thus in each instance where only a single programme line comes from an input unit, this line will be connected directly to the proper call gate G*r* whereas in every case where a plurality of programme lines come from an input unit, the plurality of programme lines will connect through an OR gate to the call gate G*r* for the input unit. If, for instance, in the input unit 2 the programme line *p*22 is marked, then the gate O2 will be unblocked, the output thereof being connected via the line *o*2 with the one input of G*r*2. If now the counter Z assumes the position *z*2, then G*r*2 will be unblocked and the control lead *s*2 will be energized, and via *s*2 the connection of the information-transmission path will be effected. Concurrently, via the control lead S*p*2 and the gate G*p*22, and in connection with the marking of the programme line *p*22, the input line *pe*3 of the electronic programme-selector will be energized, thus selecting programme number 3.

The arrangement of the line finder as well as of the various gates in the gating arrangements chiefly depends on the different types of input- and output-units. For example, if these units are magnetic storage devices, it will be appropriate to employ electronic switches as controllable switches in the line finder within the gating arrangements and in the electronic programme-selector. However, if the central processing station is supposed to cooperate with electromechanical input- and output-units, then it is preferable to employ as controllable switches of the electromechanical type, such as telegraph relays.

From the above mentoned exemplified embodiments it will be seen that the automatic programme control enables a cooperation of the central processing station with a plurality of input- and output-units. The advantages of a data processing system designed in accordance with this invention will become particularly evident in cases where the time required for an input unit to provide data for processing and to achieve a ready-to-transmit condition is substantially longer than the processing time itself. Such a relationship with respect to time will always exist when the data are fed in by hand, e.g. in the above mentioned example relating to the recording of incoming and outgoing goods. Such operations occur in an arbitrary order of succession and require different programmes. For each recording or booking operation, the respective item or list number has to be fed in as well as the piece number. When feeding in this data via a keyboard several seconds are required. The processing of the feed-in data within an electronic booking system, however, only requires a few milliseconds. On account of the electronic programme control the central booking system is now in position to deal with a great number of input-units which are operated in parallel by several operators. In this case it is appropriate to feed the information to be processed to the input-units at first, i.e. in the present example, the item number as well as the piece number, and to actuate the programme key only thereafter, for marking the desired programme line, e.g. the programme line for effecting a recording of incoming goods or the recording of outgoing goods, or for marking the respective call line associated with the input-unit. Of course, several programme keys may be provided on one input- or output-unit in order, for instance, to return an indication of stock figures relating to the respective item to the input operator's position.

In many cases of practical application a fixed assignment exists between a certain type of input device and a certain type of output device. Thus, it is possible, in an automatic booking system and on account of an existing order, to couple the item-to-price translation to the booking operation relating to the recording of outgoing goods. In this case it is appropriate to provide one common programme line for the combined input- and output-unit corresponding to this translation.

A programme control according to the invention may also be employed in a data processing system comprising several processing units serving different functions. In such a case it is appropriate to arrange the programming circuit in such a way that the call or programme lines control a selector for processing units.

If the data processing system is supposed to cooperate with input devices for evaluating mechanically readable information record means, then the programme lines are advantageously marked via an evaluating circuit for instruction signals.

While we have described above the principles of our invention 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 our invention as set forth in the objects thereof and in the accompanying claims.

What is claimed is:

1. Computing apparatus or the like, comprising a plurality of data handling units, each with a data transmission line and with at least one programme line, data processing means common to said units for carrying out directed programs of data processing operations, first gating means conditionable to connect the data transmission lines of the data handling units selectively with the data processing means, program selecting means for directing the data processing means to carry out selected programs as called for by marked programme lines of the units connected by said first gating means, second gating means conditionable to apply the effect of marked programme lines of the data handling units selectively to the program selecting means to operate the latter for selecting the program for the data processing means, unit selecting means for concomitantly conditioning the first and second gating means respectively to connect the transmission line of only one selected data handling unit at a time to the data processing means and to apply the effect of a marked programme line of this same unit to the program selecting means and means coupled to said data handling units for conditioning said unit selecting means.

2. Apparatus according to claim 1, the second gating means including AND gates, one for each programme line, each gate having one input connected with the related programme line and another input connected with said unit selecting means so as to be effective upon concurrent marking of its inputs by the programme line and the unit selecting means to apply program selecting potential to the program selecting means.

3. Apparatus as in claim 1, the data handling units including input units with transmission lines energizable to manifest data for transmission to the data processing means, said first gating means including AND gates having their outputs connected to the data processing means, each gate being assigned to one input unit and having an input connected to the transmission line of the assigned unit and another input connected to and selectively energizable by said unit selecting means.

4. Apparatus as in claim 1, wherein said means for conditioning said unit selecting means includes a call line from each data handling unit connected to said unit selecting means and energizable to signal the unit selecting means of the readiness of the data handling unit to be selected for connection of its transmission line through the first gating means with the data processing means and for connection of its programme line through the second gating means with the program selecting means.

5. Apparatus as in claim 4, the unit selecting means including a line finding counter having successive unit

selecting positions, means for stepping the counter from one position to the next to scan the call line of one data handling unit after another, and means operable under control of the counter and the first call line found thereby to be energized for interrupting stepping of the counter at a position for selecting the data handling unit related to the controlling call line.

6. Apparatus as in claim 1, the unit selecting means including a line finding device having successive positions corresponding to different ones of the data handling units, means for stepping the device from position to position to scan the units for ready signals, and means controlled by the device and first ready signal encountered upon scanning for effecting the conditioning of said first gating means to connect the data processing means to the transmission line of the data handling unit responsible for the controlling ready signal.

7. Apparatus as in claim 6, the means controlled by the device and ready signal also interrupting stepping of the device to maintain the device in the position corresponding to the data handling device responsible for the controlling ready signal until this signal is withdrawn.

8. Apparatus as in claim 7, said ready signals being

obtained from the data handling units through their programme lines when marked.

9. Apparatus as in claim 8, some of the data handling units being provided with a plurality of programme lines, and an OR gate operated by marking of any of the plurality of programme lines of a data handling unit for producing the ready signal for this unit.

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