CONVENTION

AUSTRALIA

Patents Act

618800

APPLICATION FOR A STANDARD PATENT

Heidelberger Druckmaschinen Aktiengesellschaft
Kurfursten-Anlage 52-60, D-6900 Heidelberg, FEDERAL REPUBLIC OF GERMANY

hereby applies for the grant of a standard patent for an invention entitled:

SYSTEM FOR ~~THE DETECTION OF THE~~ DETERMINING POSITION OF ~~MOVING~~ MOVABLE MACHINE PARTS

which is described in the accompanying complete specification.

Details of basic application(s):-
P 38 15 534.6 FEDERAL REPUBLIC OF GERMANY
6 May 1988

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DATED this TWENTY SEVENTH day of APRIL 1989

PHILLIPS ORMONDE & FITZPATRICK
Attorneys for:
Heidelberger Druckmaschinen Aktiengesellschaft

By:

Our Ref : 127428
POF Code: 1386/1386

AUSTRALIAN PATENT OFFICE

27/04/89

6010

FORM 8 CONVENTION

AUSTRALIA

A-570

Patents Act

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT

In support of the Convention Application made for a patent for an invention entitled:

SYSTEM FOR THE DETECTION OF THE POSITION OF MOVING MACHINE PARTS

I, Wolfgang Pfizenmaier and Baldur Stoltenberg of HEIDELBERGER DRUCKMASCHINEN AKTIENGESELLSCHAFT (Full Name)

of Kurfürsten-Anlage 52-60, 6900 Heidelberg (Full Address)

do solemnly and sincerely declare as follows:

1. I am authorized by Heidelberger Druckmaschinen Aktiengesellschaft, the applicant for the patent to make this declaration on its behalf.

2. The basic application/s as defined by section 141 of the Act were made in FEDERAL REPUBLIC OF GERMANY on 6 May 1988,.

3. Dieter Hauck: Hohenweg 36, 6930 Eberback, Karl-Heinz May: Hansstrasse 13a, 6806 Viernheim, Hans Muller: Albrecht-Durer-Strasse 15, 6902 Sandhausen and Jurgen Rehberger: Talstrasse 3, 6915 Dossenheim all respectively in Federal Republic of Germany is/are the actual inventor/s of the invention and the facts upon which Heidelberger Druckmaschinen Aktiengesellschaft is entitled to make the application are as follows:

   The applicant is the assignee of the actual inventor/s.

4. The basic application/s referred to in paragraph 2 of this Declaration was the first application made in a Convention country in respect of the invention the subject of the application.

Declared at Heidelberg this 10 day of May 19 89

Heidelberger Druckmaschinen

Wolfgang Pfi ... (Signature)

(Typed Name)

Wolfgang Pfizenmaier Baldur Stoltenberg

To: The Commissioner of Patents

PHILLIPS ORMONDE & FITZPATRICK
Our Ref : 127428
POF Code: 1386/1386

6025

(12) PATENT ABRIDGMENT (11) Document No. AU-B-33761/89
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SYSTEM FOR DETERMINING POSITION OF MOVABLE MACHINE PARTS

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(56) Prior Art Documents
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AU 478445 78840/75 G01B 7/30
AU 20855/67 G01B 11/26 56.4

(57) Claim

1. System for determining position of movable machine parts, including an incremental pulse generator for generating angular-speed pulses, comprising a computer, and at least one counting circuit via which the incremental pulse generator is connected to said computer for counting the generated angular-speed pulses, wherein said counting circuit includes a plurality of counters, and including means for deriving further pulses having a frequency which is a given multiple of the frequency of the angular-speed pulses, the incremental pulse generator being connected to at least one of said counters for delivering output signals thereto forming more significant figures of the count, said means for deriving further pulses being connected to a further one of said counters for delivering an output signal thereto forming less significant figures of the count.

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COMPLETE SPECIFICATION
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Complete Specification for the invention entitled:

SYSTEM FOR DETERMINING ~~THE DETECTION OF THE~~ POSITION OF MOVABLE ~~MOVING~~ MACHINE PARTS

Our Ref : 127428
POF Code: 1386/1386

The following statement is a full description of this invention, including the best method of performing it known to applicant(s):

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The invention relates to a system for determining position of movable machine parts, particularly the angular position of rotating parts of a printing press, including an incremental pulse generator for generating angular-speed pulses which are counted.

When controlling machines by means of computers, it is frequently necessary to determine the position of movable machine parts and to release or initiate specific operations at given positions. Thus, for example, a machine may be stopped when it reaches a specified position. In addition, further functions and operations may be controlled during the running of the machine. This may require a considerable proportion of available computer capacity particularly in the case of printing machines. In this regard, continuous monitoring of the position of the machine demands considerable computer time - particularly if, the respective position is to be determined with great accuracy in a high speed printing machine.

An object of the present invention is to provide a system for determining position of movable machine parts, particularly the angular position of rotating parts of a printing machine wherein loading of the computer is alleviated despite high resolution and/or high machine speed.

The present invention provides a system for determining position of movable machine parts, including an incremental pulse generator for generating angular-speed pulses, comprising a computer, and at least one counting circuit via which the incremental pulse generator is connected to said computer for counting the generated angular-speed pulses, wherein said counting circuit includes a plurality of counters, and including means for deriving further pulses having a frequency which is a given multiple of the frequency of the angular-speed pulses, the incremental pulse generator being connected to at least one of said counters for delivering output signals thereto forming more significant figures of the count, said means for deriving further pulses being connected to a further one of said counters for delivering an output signal thereto forming less significant figures of the count.

In a further development of the system a comparator may preferably be provided, said comparator being able to be supplied with the current count from the counter circuit and with a setpoint value from the computer, an output of the comparator being connected to an input of the computer for program interruption.

This further preferred development makes it possible in advantageous manner, after a specified position has been detected and after a further specified position has been outputted, for the computer to operate without program interruption until the machine has reached the further specified position. Consequently, considerably more computing time is available for the actual open-loop and/or closed-loop control tasks of the computer.

According to other further developments of the system it is preferably provided that further pulses are derived, the frequency of said further pulses corresponding to a selected multiple of the frequency of the angular-speed pulses, the further pulses being counted instead of the angular-speed pulses or that the further pulses are supplied to a further counter, the output signal of said counter forming lower-order digits of the count, while the output signals of the counter represent higher-order digits of the count.

These further preferred developments provide a higher degree of resolution in the detection of the position without it being necessary to make any changes to the incremental pulse generator, which may consist, for example, of an optical index disc. Furthermore, the derivation and evaluation of the further pulses may be switched off at high machine speeds.

According to another further development of the system, an increase in resolution may also preferably be achieved when the counter is incremented or decremented both by the leading edges and also by the trailing edges of the angular-speed pulses of two phase-displaced angular-speed signals.

The further pulses may be derived in an advantageous manner by an apparatus which is provided for measuring the speed of the machine, the frequency of the further pulses being calculated in the computer.

Another further preferred development of the system consists in two 90^{o}-phase-displaced angular-speed signals being generated and being supplied to the counter via a combinational circuit. This further development improves the reliability of the system with regard to malfunctions that may occur in the area of the incremental pulse generator and the leads. For this purpose, the angular-speed signals are preferably combined with one another in the combinational circuit in such a manner that the angular-speed pulses are counted only if there is an allowable combination of the angular-speed signals.

The following description refers in more detail to the various features of the system of the present invention. To facilitate an understanding of the invention, reference is made in the description to the accompanying drawings where the system is illustrated in preferred embodiments. It is to be understood that the system of the present invention is not limited to the preferred embodiments as illustrated in the drawings.

Fig. 1 shows an arrangement for the evaluation of angular-speed signals with a specimen embodiment of the system according to the invention;

Fig. 2 shows a counter circuit used with the specimen embodiment;

Fig. 3 shows a further counter circuit;

Fig. 4 shows a combinational circuit that is part of the circuits shown in Fig. 2 and 3;

Fig. 5 shows timing diagrams of some signals used in the arrangement shown in Fig. 2;

Fig. 6 shows an automata graph for explaining the operating principle of the combinational circuit; and

Fig. 7 shows a further combinational circuit.

Indentical parts in the Figures are provided with identical reference characters.

The arrangement shown in Fig. 1 features a known incremental pulse generator 1. Such incremental pulse generators may consist, for example, of an index disc provided with optical markings, said index disc being scanned by optoelectric receivers. In this connection, one of the optoelectric receivers supplies a pulse O during one revolution. Furthermore, angular-speed signals A and B are generated, said [illegible] being wave-form and being 90°-phase-displaced with respect to one another. In a customary incremental pulse generator, the angular-speed signals A and B each comprise 1,024 pulses per revolution.

The angular-speed signals O, A and B are supplied to inputs of a changeover switch 2, to the further inputs of which are applied electronically generated test signals Test-O, Test-A and Test-B. The changeover switch can be controlled by the computer 3 with the result that, in a test mode, the switching operations described in the following can be tested also with the machine stationary.

The angular-speed signals A and B are evaluated in order to detect the direction of rotation and the position as well as in order to measure the speed or rotational speed. In order to detect the direction of rotation, the angular-speed signals A and B are supplied to a circuit 4. The circuit 4 comprises two outputs 5, 6, with output 5 supplying a signal to identify the direction of rotation and with output 6 supplying a pulse in the event of a change in the direction of rotation. While the direction-of-rotation identification signal is supplied to a data input of the computer, the pulse at output 6 generates a program interrupt (IR).

The rotational speed is measured with two counters 8, 9, which are supplied via a changeover switch 7 and a frequency divider 17 with the angular-speed signals A and B, respectively. In this connection, the changeover switch 7 is controlled by a circuit 18 in such a manner that, if one of the angular-speed signals fails, the other signal is passed on. The frequency divider 17 is programmable, for which purpose the respective divider ratio is supplied by the computer 3 via the data bus 10. The counters 8, 9 are supplied with a reference signal, the frequency of which is considerably higher, according to the degree of resolution of rotational-speed measurement, than the frequency of the angular-speed signals. In order also at high rotational speeds to obtain a high degree of resolution of rotational-speed measurement without the counters 8, 9 overflowing at low rotational speeds, it is possible for the frequency of the reference signal to be varied. For this purpose, an appropriate value is supplied via the bus system 10 to the oscillator 11 for the reference signal.

The rotational speed is measured in such a way that, in alternating manner, one of the counters counts the pulses of the reference signal between two pulses supplied by the frequency divider 17. After counting is finished, a program interrupt (IR) is triggered, whereupon the computer reads the count via the data bus 10. In the meantime, the other counter has already been started, with the result that the duration of each period of the output signals from the frequency divider 17 is measured. The measured values are converted in the computer 3 into rotational-speed values.

Since a program interrupt is triggered each time to enable the computer to read the count, this means that other program sequences in the computer are disrupted. In order to prevent these disruptions from occurring too frequently, the frequency of the angular-speed signals A and B is divided - as already described - at higher rotational speeds. The data bus and the computer are represented in greatly simplified form, because suitable circuits and devices are sufficiently known.

In order to detect the position, the angular-speed signals A and B and the pulse 0 are supplied to a counter circuit 12. In addition, it is provided that the pulse 0 triggers a program interrupt. The counter circuit is reset by the pulse 0, so that the count gives the position or rotation angle with reference to a starting position. In the arrangement according to Fig. 1, this value is supplied as the actual position to a comparator 13, where it is compared with a setpoint position, which was previously written to a register 14 by the computer. When the machine has arrived at the setpoint position, both values are identical and the comparator 13 triggers a program interrupt, whreupon the computer initiates the action that has been planned for the setpoint position. Directly thereafter, a new setpoint position can be inputted via the register 14. Until the machine reaches this new setpoint position, it is not necessary for the position of the machine to be continuously measured in the computer.

In order to increase the degree of resolution in the measurement of the position, the counter circuit may be supplied with additional pulses from an additional-pulse generator 15, the frequency of said additional pulses corresponding to a multiple of the frequency of the angular-speed signals. For this purpose, the oscillator 15 is controlled by the computer 3 on the basis of frequency measurement with the aid of the circuits 7 to 11. The counting of the additional pulses yields the lower-order digits of the actual position that is supplied to the comparator 13. Owing to the inertia of the machine, the frequency of the angular-speed signals does not change with excessive speed, with the result that frequency measurement and thus the control of the oscillator 15 are performed with sufficient accuracy for the following periods of the angular-speed signal.

Fig. 2 shows a specimen embodiment of the counter circuit 12 (Fig. 1) in which three 4-bit counters of type LS 669 are provided. Carry outputs of the counters 21 and 22 are connected to inputs of the counters 22 and 23, so that the overall result is a 12-bit counter. The angular-speed signals A and B are supplied via inputs 24, 25 to a combinational circuit 26, where, through logical combination with the two lower-order digits Q1 and Q2 of the count, and up/down signal $U/\overline{D}$ and a counter-enabling signal $\overline{ENA}$ are derived. In addition, the combinational circuit 26 is supplied via inputs 27, 28 with the signals DR-input and DR-enable. The signal DR-input identifies the direction of rotation of the machine. The signal DR-enable states whether the rotational speed of the machine is above or below a rotational speed at which a change in direction can take place. A further input 29 is provided for the pulse 0, which controls the LOAD input and thus resets the counters, because data inputs A and D are connected to frame potential. Finally, the counter circuit 12 comprises an input 30 for a clock signal CLK.

As previously explained in conjunction with Fig. 1, the degree of resolution in measuring the position can be increased in that, with the aid of an oscillator 15, further pulses are generated the frequency of which is a multiple of the frequency of the clock singals. In the specimen embodiment shown in Fig. 3, the oscillator 15 generates pulses of a frequency 64 times that of the angular-speed signals, with these pulses being supplied to a further counter 31 of type LS 669. The counting direction of the further counter 31 is controlled by the signal DR-input. Thus, the count is extended to 16 digits (Q1' to Q4', to Q1 to Q12) and the degree of resolution is increased to 16-fold, since a four-fold counting frequency is already obtained by the evaluation of both edges of the angular-speed signals A and B. With 1,024 pulses per full circle, the angular resolution is, accordingly, 360/4,096 = 0.0879 degrees without the further counter 31 and 360/(4,096*16) = 0.0055 degrees with the further counter 31.

Fig. 4 shows a specimen embodiment of the combinational circuit 26 in which the signals DR-enable and DR-input are not taken into consideration. The combinational circuit comprises an exclusive-OR element 41 as well as two equivalence elements 42, 43. The angular-speed signals A, B are supplied via the inputs 24, 25 to both inputs of the exclusive-OR element 41. The output of the exclusive-OR element 41 is connected to an input of the equivalence element 43, the other input of which is connected to the least-significant bit (LSB) Q1. The enable signal $\overline{ENA}$ for the counter can be picked off at the output 44. In order to obtain an up/down signal $U/\overline{D}$, the angular-speed signal A as well as the second-least-significant digit Q2 of the count are supplied to the equivalence element 42, at the output 45 of which the signal $U/\overline{D}$ can be picked off.

The operating principle of the combinational circuit shown in Fig. 4 in conjunction with the counter shown in Fig. 2 is explained in greater detail in the following with reference to Fig. 5. Fig. 5 shows timing diagrams for signals 0, A and B for a given direction of rotation, for example for clockwise rotation. Furthermore, values for Q1 and Q2 of the counter 21 and the entire count Q1 to Q12 are given in Fig. 5. Finally, the Q1' to Q4' (Fig. 3) is indicated.

The signal 0 occurs once during each revolution, while the angular-speed signals A and B occur more frequently, depending on the divisions of the incremental pulse generator - for example 1,024 times per revolution. The angular-speed signals A and B are 90^{o}-phase-displaced with respect to one another. The counter is reset by the pulse 0, with the result that the count becomes 0 and, therefore, the two lower-order digits Q1 and Q2 also assume the value 0. After the first subsequent edge of the angular-speed signal A, A and B are no longer identical, with the result that the value 1 is present at the output of the exclusive-OR element 41. Through combination with Q1 = 0 in the equivalence element 43, the output 44 likewise becomes 0, which effects the enabling of the counter. Since, at this time, Q2 = 0 and A becomes = 0, $U/\overline{D}$ becomes = 1, which effects the incrementing of the counter (counting up).

The incrementing of the counter makes Q1 = 1, which means, in turn, that with the following edge of the angular-speed signal B, the equality of the angular-speed signals A and B leads to $\overline{ENA}$ = 0, with the result that there is a further incrementing of the counter.

At the beginning of the following quarter-period of the angular-speed signals, the signal A jumps to 1. Since, however, Q2 is likewise = 1, $U/\overline{D}$ becomes = 1. Since, furthermore, A and B are not identical, but Q1 = 0, the result is $\overline{ENA}$ = 0, so that the counter is once again incremented.

In order further to explain the operating principle of he combinational circuit shown in Fig. 4 in conjunction with the counter circuit, particularly with the counter 21 (Fig. 2), reference is made in the following to the automata graph shown in Fig. 6. According to this, the combinational circuit 26, including the two lower-order digits of the counter 21, can assume the states Z0, Z1, Z2 and Z3. The values present in these states at the outputs Q1 and Q2 are given in the circles representing the states. A transition from one state to another can be effected only by counting up or down, which is indicated in Fig. 6 by arrows between the circles. In this connection, the figures next to the arrows signify the values of the angular-speed signals A and B necessary for the respective transition. Thus, for example, a transition from state Z0 to state Z1 is caused by A = 0 and B = 1. If, afterwards, B becomes = 0, the combinational circuit switches to state 2.

The filter effect of the combinational circuit is explained with reference to the example of a spurious pulse 46 (Fig. 5). Prior to the spurious pulse, the combinational circuit is in state Z3. Owing to the fact that, during the spurious pulse 46, the angular-speed signal B assumes the value 1, there is a switch to state Z0, since the angular-speed signal A is also = 1. At the end of the spurious pulse, however, B again becomes = 0, with the result that the combinational circuit is reset to state Z3. The counter is, therefore, incremented by the spurious pulse 46; after the spurious pulse, however, the counter is again decremented, with the result that there is no falsification of the count.

The effect of the combinational circuit shown in Fig. 4 is, therefore, that, in any state, the only adjacent states are allowed. The count 0 can, therefore, be followed only by one of the counts 1 or 4,095. A further increase in operational reliability is achieved by the inputting of the direction of rotation via the computer 3 (Fig. 1). In this connection, a change in the direction of rotation indicated by the angular-speed signals A and B is recognized as an error if this is in contradiction with the DR-input signal that has been supplied by the computer. With the machine stationary or at low rotational speeds, however, this additional check may lead to errors and is therefore switched off if, because of low rotational speeds, a change of direction of rotation is possible. Therefore, the computer supplies a further Dr-enable signal, which above a given rotational speed, assumes the value 1.

The combinational circuit shown in Fig. 7 contains, in addition to the components previously described in conjunction with Fig. 4, an exclusive-OR element 50, an AND element 51 and an OR element 52. The output signal $\overline{ENA}$ of the equivalence element 43, which, with the combinational circuit according to Fig. 4, disables ($\overline{ENA}$ = 1) or enables ($\overline{ENA}$ = 0) the counter, is once again filtered by an OR element 52 in the combinational circuit shown in Fig. 7. The output signal $\overline{ENA}'$ of this OR element 52 is supplied via the output 53 to the counter. If the value 0 is present at the lower input of the OR element 52, $\overline{ENA}'$ becomes = $\overline{ENA}$, with the result that the combinational circuit shown in Fig. 6 operates like the combinational circuit shown in Fig. 4. If, however, there is a 1 at the lower input, the output 53 is set to 1 irrespective of the value of $\overline{ENA}$, which effects the disabling of the counter.

This disabling of the counter can, however, take place only if both inputs of the AND element 51 are supplied with the value 1. This is the case if both the signal DR-enable has the value 1 and also the two direction-of-rotation identification signals U/$\overline{D}$, obtained independently of one another, and DR-input are different from one another.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. System for determining position of movable machine parts, including an incremental pulse generator for generating angular-speed pulses, comprising a computer, and at least one counting circuit via which the incremental pulse generator is connected to said computer for counting the generated angular-speed pulses, wherein said counting circuit includes a plurality of counters, and including means for deriving further pulses having a frequency which is a given multiple of the frequency of the angular-speed pulses, the incremental pulse generator being connected to at least one of said counters for delivering output signals thereto forming more significant figures of the count, said means for deriving further pulses being connected to a further one of said counters for delivering an output signal thereto forming less significant figures of the count.

2. System according to claim 1, including a comparator having respective inputs connected to an output of said counting circuit for receiving a count signal therefrom, and to an output of said computer for receiving a given value signal therefrom, said comparator having an output connected to another input of said computer for feeding a program-interrupt signal thereto.

3. System according to claim 1 or 2, including a device for measuring the speed of the machine, said computer having means for computing the frequency of said further pulses.

4. System according to any one of the preceding claims, wherein the incremental pulse generator is capable of generating two angular-speed pulses shifted 90° out of phase from one another, and including a combinatorial circuit connected to said counting circuit and via which the two 90° phase-shifted angular-speed pulses are fed to said counting circuit.

5. System according to claim 4, including means for combining the angular-speed pulses in said combinatorial circuit in a manner that the angular-speed pulses are

counted only if a permissible combination of the angular-speed pulses exists.

6. System according to any one of the preceding claims wherein at least one of said counters is respectively incremented and decremented both from leading edges and trailing edges of the angular-speed pulses of two phase-shifted angular-speed signals.

7. System for determining position of movable machine parts substantially as herein described with reference to the accompanying drawings.

DATED: 18 October, 1991.

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AUSTRALIAN PATENT OFFICE
MJP

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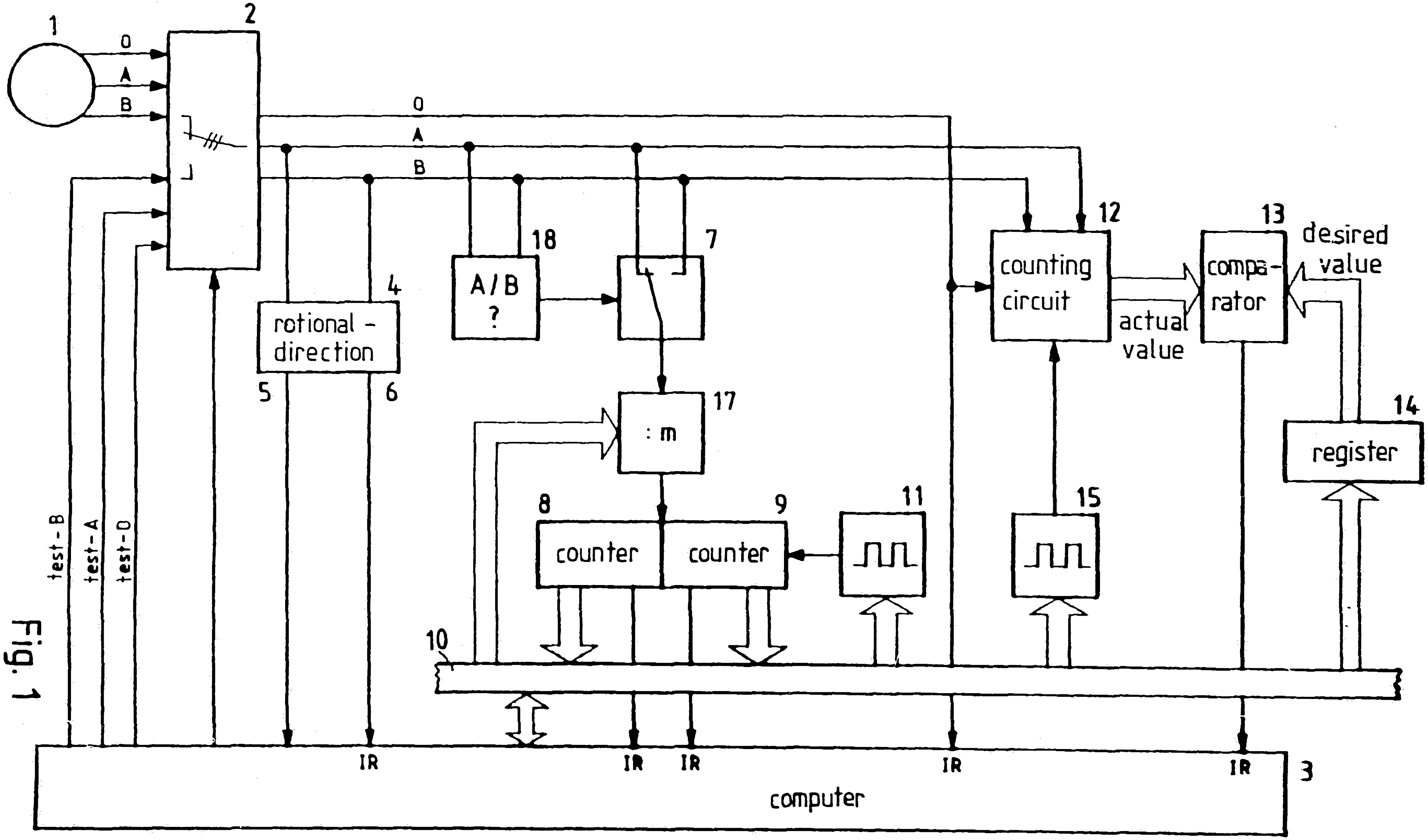

Fig. 1

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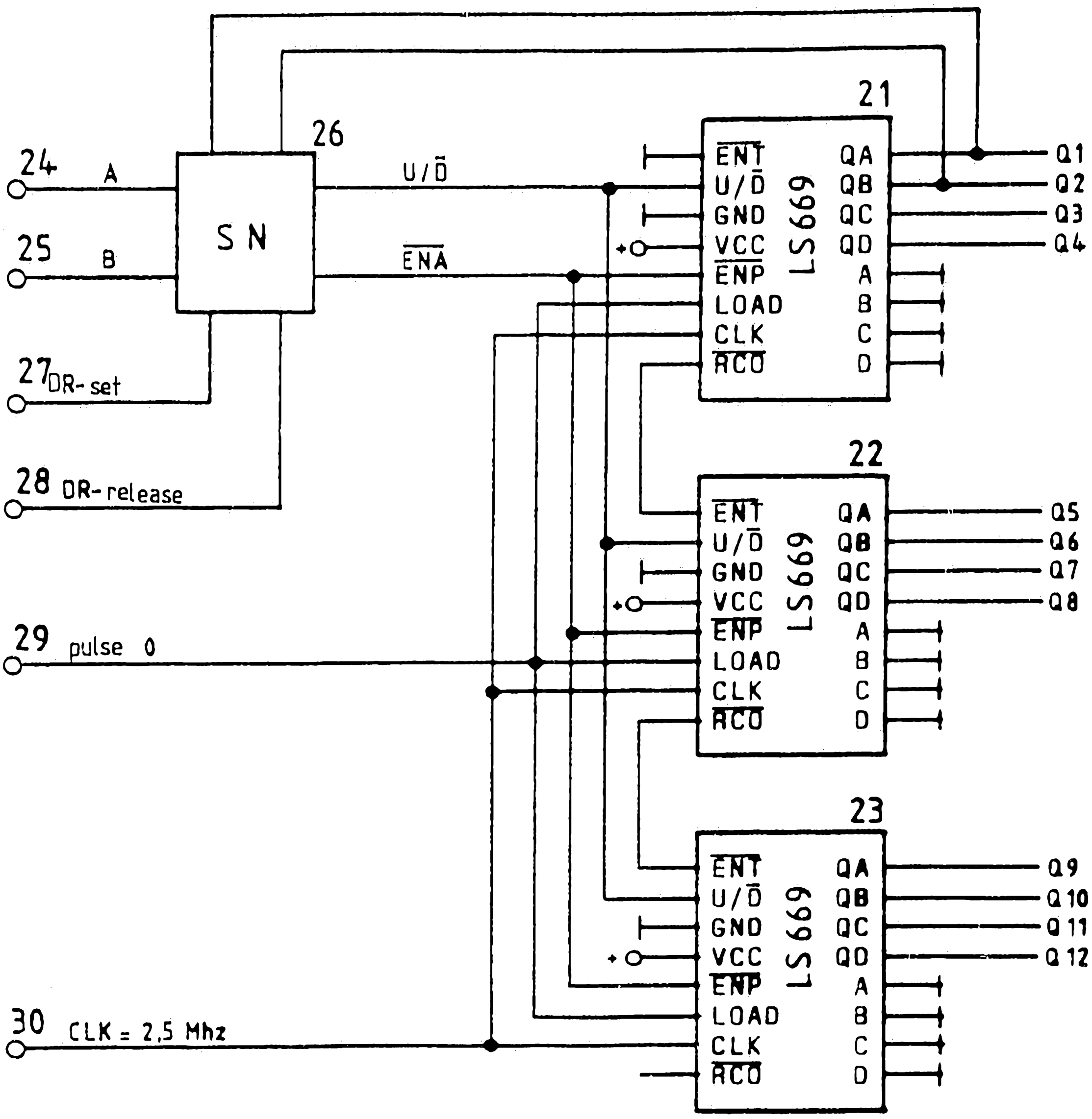
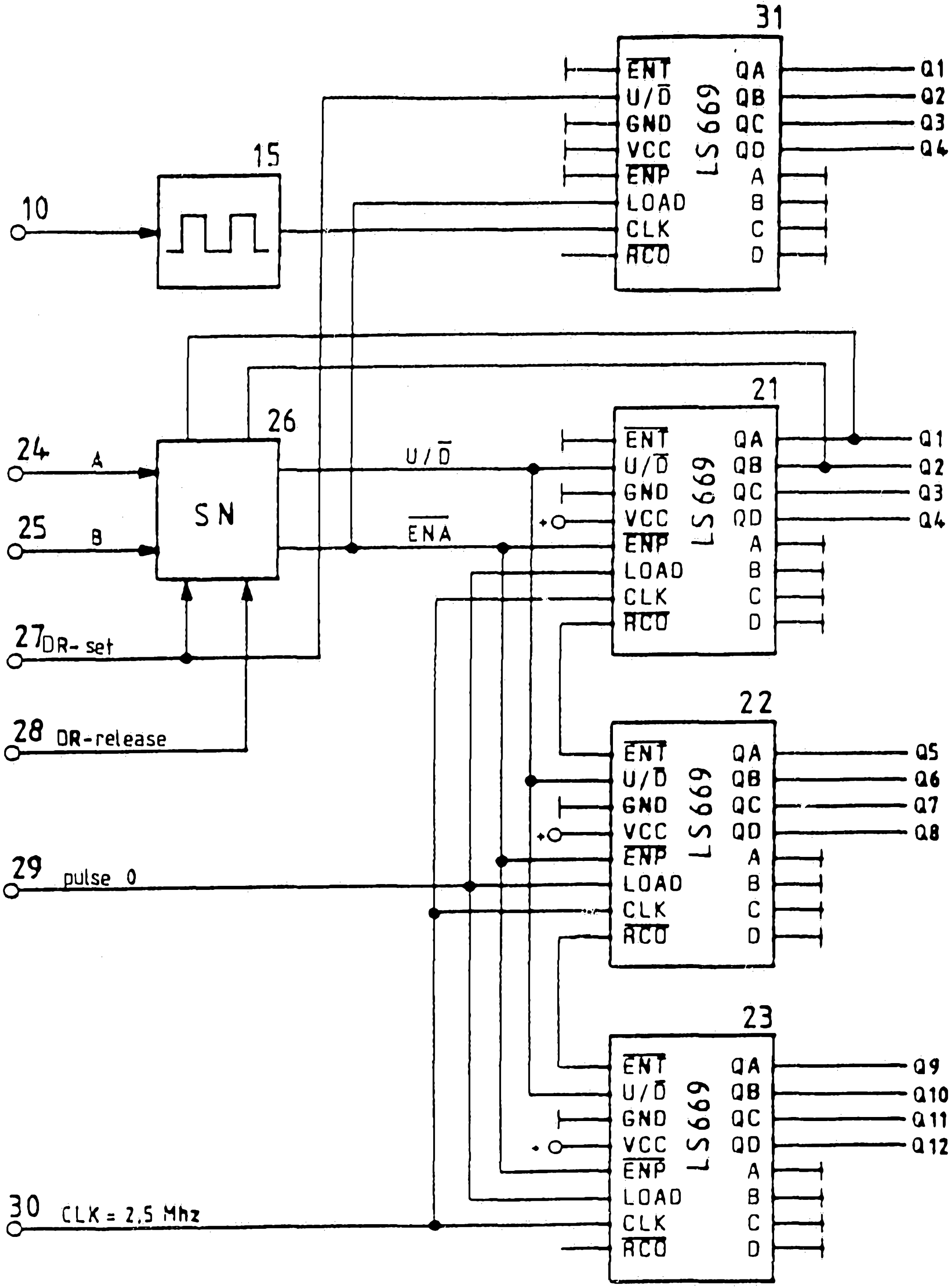


24
A
25
B
SN
26
U/D̄
ENA
27 DR-set
28 DR-release
29 pulse 0
30 CLK = 2,5 Mhz
21
22
23
ENT
U/D̄
GND
VCC
ENP
LOAD
CLK
RCO
LS669
QA
QB
QC
QD
A
B
C
D
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12

Fig. 2



31
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GND
VCC
ENP
LOAD
CLK
RCO
LS 669
QA
QB
QC
QD
A
B
C
D
Q1
Q2
Q3
Q4
15
10
21
Q5
Q6
Q7
Q8
22
23
Q9
Q10
Q11
Q12
26
24
A
25
B
SN
U/D
ENA
27 DR- set
28 DR-release
29 pulse 0
30 CLK = 2,5 Mhz

Fig. 3

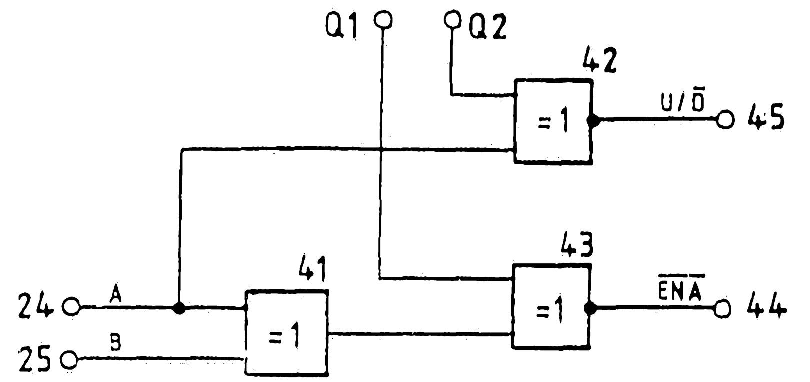


Fig. 4

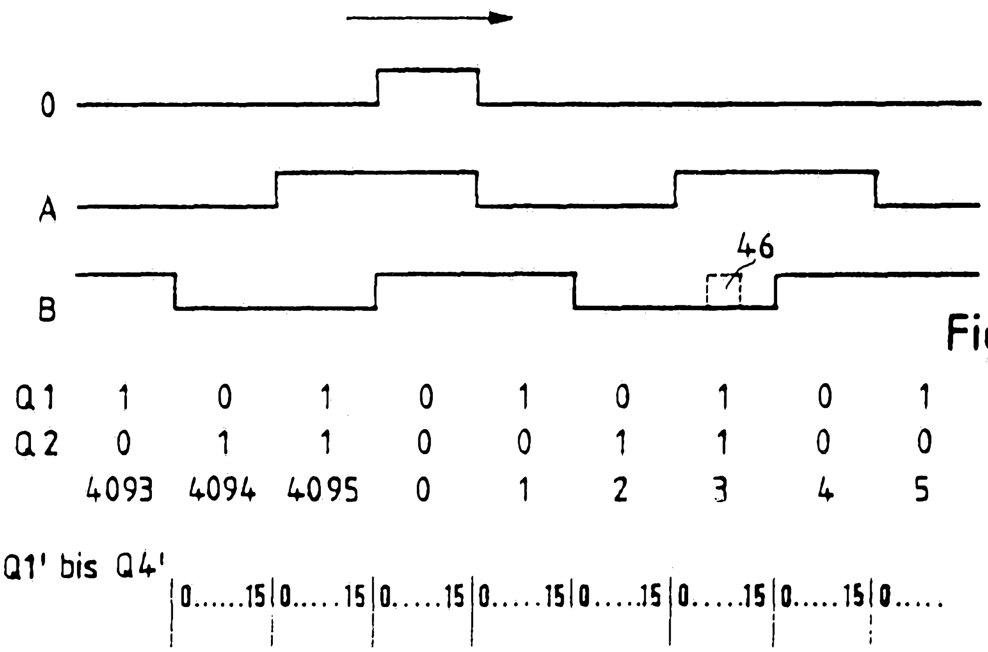


Fig. 5

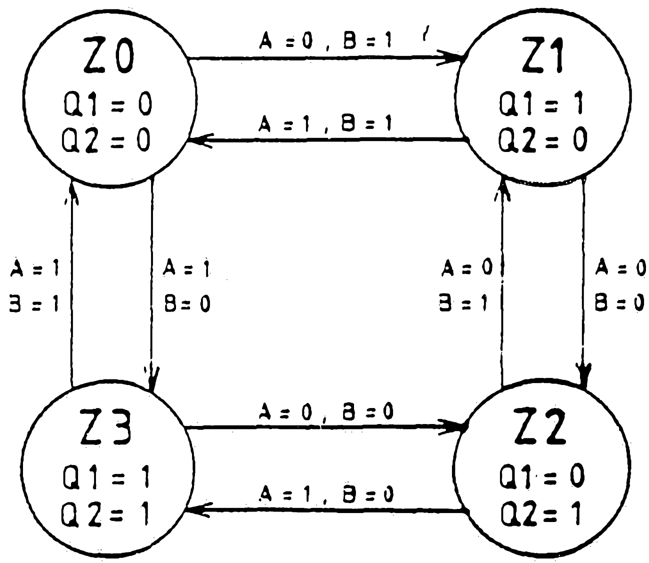
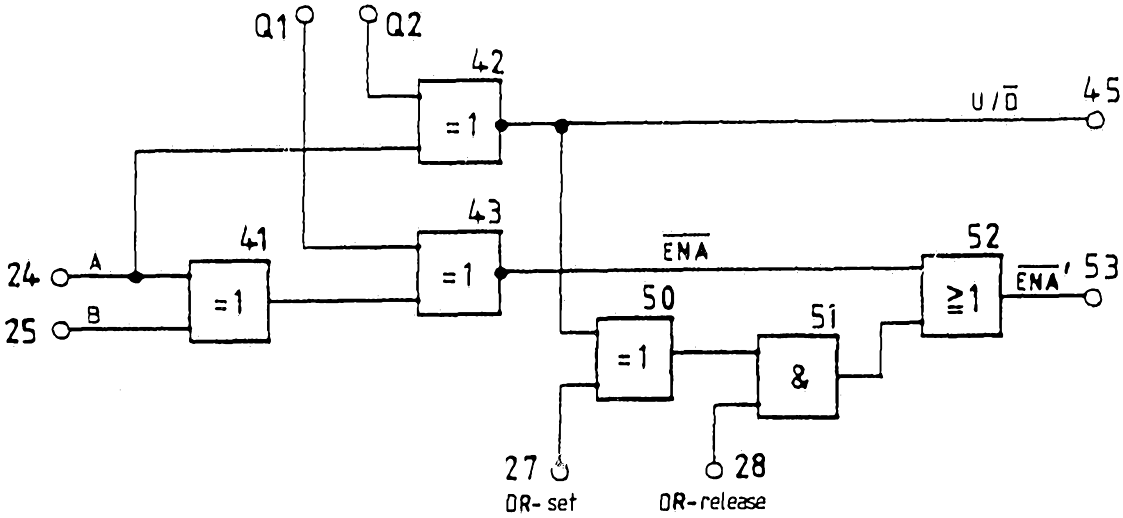


Fig. 6


Q1
Q2
42
=1
U / D̄
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43
=1
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=1
$\overline{ENA}$
52
≥1
$\overline{ENA}$'
53
24
A
25
B
50
=1
51
&
27
DR- set
28
DR-release

Fig. 7