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(71) Applicant *(for all designated States except US)*: **RENISHAW PLC** [GB/GB]; New Mills, Wotton-under-Edge, Gloucestershire GL12 8JR (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **FUGE, Jonathan, Paul** [GB/GB]; 106 Guest Avenue, Emersons Green, Bristol, BS16 7EA (GB).

(74) Agents: **JACKSON, John, Timothy** et al.; Renishaw PLC, Patent Department, New Mills, Wotton-Under-Edge, Gloucestershire GL12 8JR (GB).

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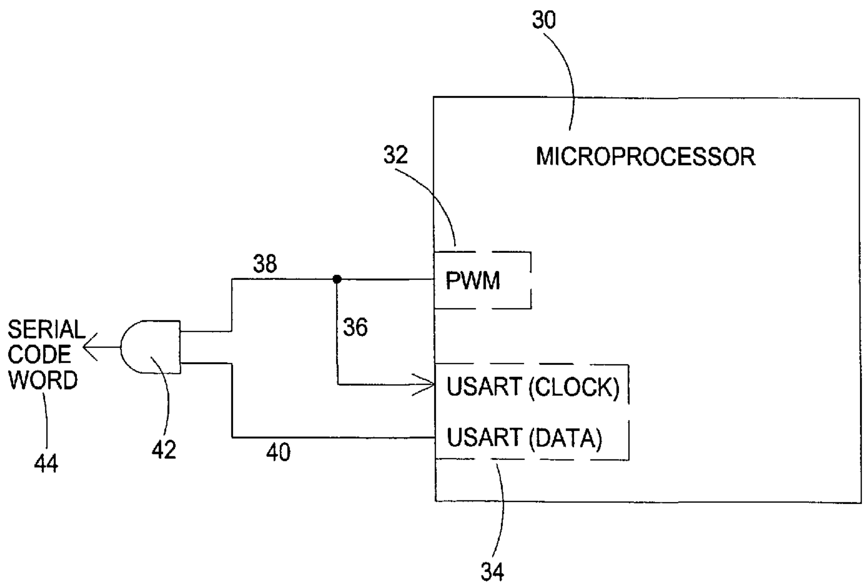
(54) Title: MACHINE TOOL PROBE



(57) **Abstract:** A probe for position determining apparatus such as a machine tool transmits optical measurement signals to a receiver module. The probe is battery powered and the battery powers light emitting diodes which transmit the optical measurement signals. The optical measurement signals comprise serially transmitted codewords which are generated by a universal synchronous / asynchronous receiver transmitter (USART). The output of the USART is combined with a pulse width modulator which has an output having the same form as the output of the USART but with reduced duration of each pulse, thus enhancing the life of the battery powering the light emitting diodes. The pulse width modulator may also be used to set the timing of the USART.

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MACHINE TOOL PROBE

This invention relates to probes for use on position determining apparatus such as coordinate measuring machines, measuring robots and in particular machine tools.

An example of such a probe is shown in US Patent No. 4,153,998. Probes intended for use on machine tools in which there is a wireless signal transmission between the probes and the controller of the machine tool are shown in European Patent Nos. 337669 and 337670.

When used on machine tools such probes are commonly battery-operated. These probes may transmit measurement signals optically to a receiver module however, the power consumption in sending these optical messages reduces the battery life.

The present invention provides a probe for position determining apparatus comprising:

signal generating means for generating a signal;

signal transmitting means for transmitting the signal generated by the signal generating means to a receiver module in the form of optical pulses;

characterised in that a pulse width modulator is provided to reduce the duration of each pulse.

Preferably the signal generating means includes a universal synchronous/asynchronous receiver transmitter. The pulse width modulator may control the timing of the universal synchronous/asynchronous receiver transmitter (USART).

Preferably the probe is battery powered. The optical pulses may be generated by LEDs.

A preferred embodiment of the invention will now be described with reference to the accompanying drawings wherein:

Fig 1 is a diagrammatic view of the probe on a machine tool;

Fig 2a is part of a codeword of optical pulses formed by the universal synchronous/asynchronous receiver transmitter (USART);

Fig 2b is the output of a pulse width modulator;

Fig 2c is the output of the universal synchronous/asynchronous receiver transmitter (USART) and pulse width modulator combined; and

Fig 3 is a schematic diagram showing the formation of a serial codeword.

Referring to Fig 1, the probe 10 is mounted in the spindle 12 of a machine tool exchangeably with the normal cutting tools. The spindle 12 can move the probe in three dimensions x,y,z relative to a workpiece 14 clamped on a table or bed 22 of the machine tool. Measurements are made by contact between the stylus 11 of the probe and the workpiece. Measurement signals from the probe are transmitted optically as indicated by arrow 16 to a receiver module 19 mounted on a fixed structure 20 of the machine tool. The probe 10 is battery operated. The battery powers LEDs located within window 18 which are used to transmit the optical measurement signals.

The optical measurement signals indicated by arrow 16 in Fig 1 comprise serially transmitted codewords. Each codeword is 8 bits long and comprises a sequence of on/off pulses. These codewords are generated by signal generating means, comprising a universal synchronous/asynchronous receiver transmitter (USART). A section of codeword formed in this way is shown in Fig 2a. Typically each pulse is 8 microseconds long and a new codeword may be transmitted every 16 milliseconds.

Using the universal synchronous/asynchronous receiver transmitter (USART) alone to generate the codewords has a disadvantage that as each pulse is relatively long this results in high power consumption and thus reduced battery life.

To overcome this disadvantage the universal synchronous/asynchronous receiver transmitter (USART) is combined with a pulse width modulator. As shown in Fig 2B, the pulse width modulator generates a regular series of pulses of shorter pulse length and with a shorter time interval between pulses than generated by the universal synchronous/asynchronous receiver transmitter (USART). The time between pulses is typically 8 microseconds and pulse length is typically 2 microseconds. The universal synchronous/asynchronous receiver transmitter (USART) output is combined with the pulse width modulator output to provide a chopped output for transmission. As shown in Fig 2c the form of this resultant output is the same as the form of the output of the universal synchronous/asynchronous receiver transmitter (USART) shown in Fig 2a, however the duration of each ON pulse has been reduced to equal that of the pulse width modulator. This reduces the duration of each LED flash and therefore reduces the power consumption of the system. Battery life is therefore enhanced.

Use of the pulse width modulator in combination with the universal synchronous/asynchronous receiver transmitter (USART) has a second advantage. In previous systems without the pulse width modulator the microprocessor must control both the timing and the sequence of the pulses, however when a pulse width modulator is incorporated into the system this may be used to set the timing of the universal synchronous/asynchronous receiver transmitter (USART), i.e. it acts as a serial clock for timing. The microprocessor is used less as it is only required to send on/off messages to the universal synchronous/asynchronous receiver transmitter (USART) and therefore has improved multi-tasking.

The pulse width modulator may already be incorporated into the probe for other uses such as motor control or digital/analogue conversion. The use of existing components in the probe for the system therefore reduces component cost.

Fig 3 is a schematic diagram showing the formation of the serial codewords. A microprocessor 30 in the probe incorporates a pulse width modulator 32 and signal generating means in the form of a universal synchronous/asynchronous receiver transmitter (USART) 34. An output 36 from the pulse width modulator 32 controls the timing of the universal synchronous/asynchronous receiver transmitter (USART). Outputs 38,40 of the pulse width modulator 32 and the universal synchronous/asynchronous receiver transmitter

(USART) 34 are combined at an AND gate 42 to form a serial codeword 44. This serial codeword is transmitted from an LED or other signal transmitting means to an external receiver.

CLAIMS

1. A probe for position determining apparatus comprising:

signal generating means for generating a signal;

signal transmitting means for transmitting the signal generated by the signal generating means to a receiver module in the form of optical pulses;

characterised in that a pulse width modulator is provided to reduce the duration of each pulse.

2. A probe according to claim 1 wherein the signal generating means includes a universal synchronous/asynchronous receiver transmitter.

3. A probe according to claim 2 wherein the pulse width modulator controls the timing of the universal synchronous / asynchronous receiver transmitter.

4. A probe according to any preceding claim wherein the probe is battery powered.

5. A probe according to any preceding claim wherein the optical pulses are generated by light emitting diodes.

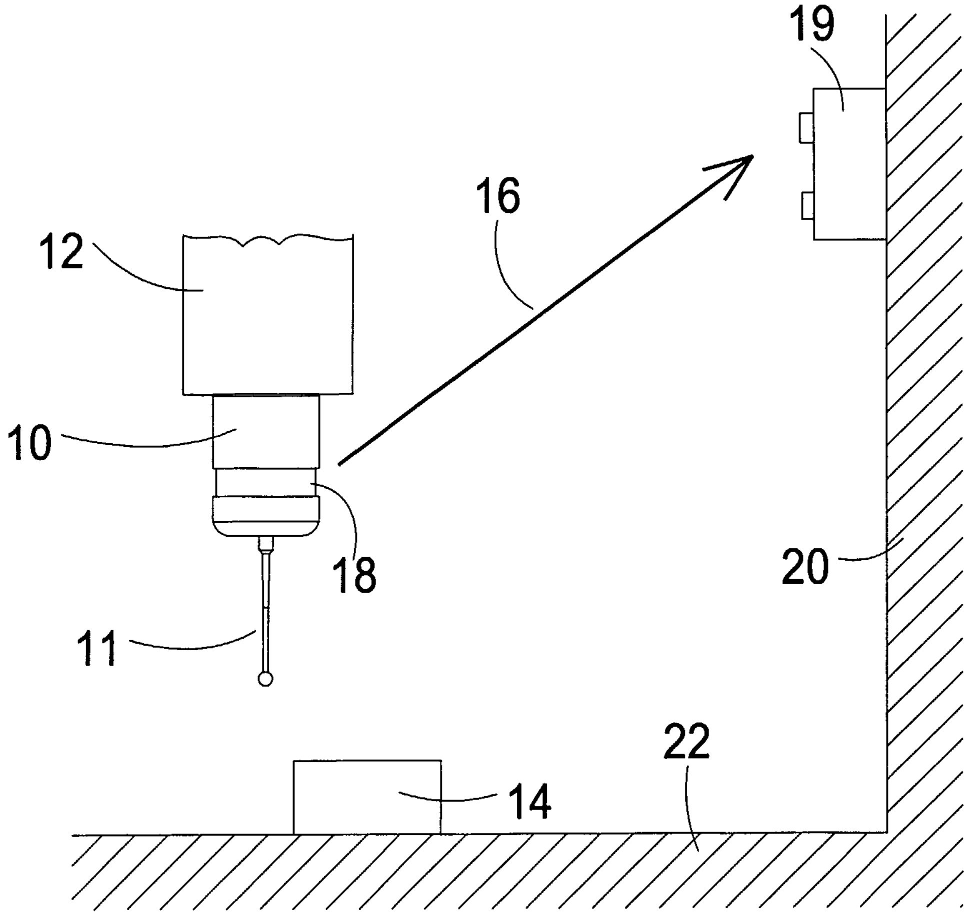

Fig 1

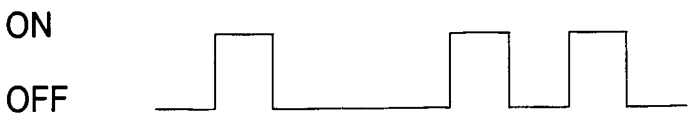

Fig 2A

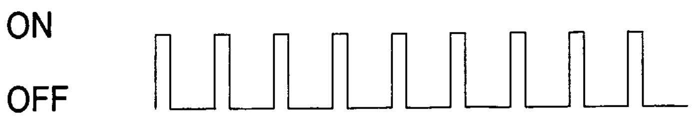

Fig 2B

Fig 2C

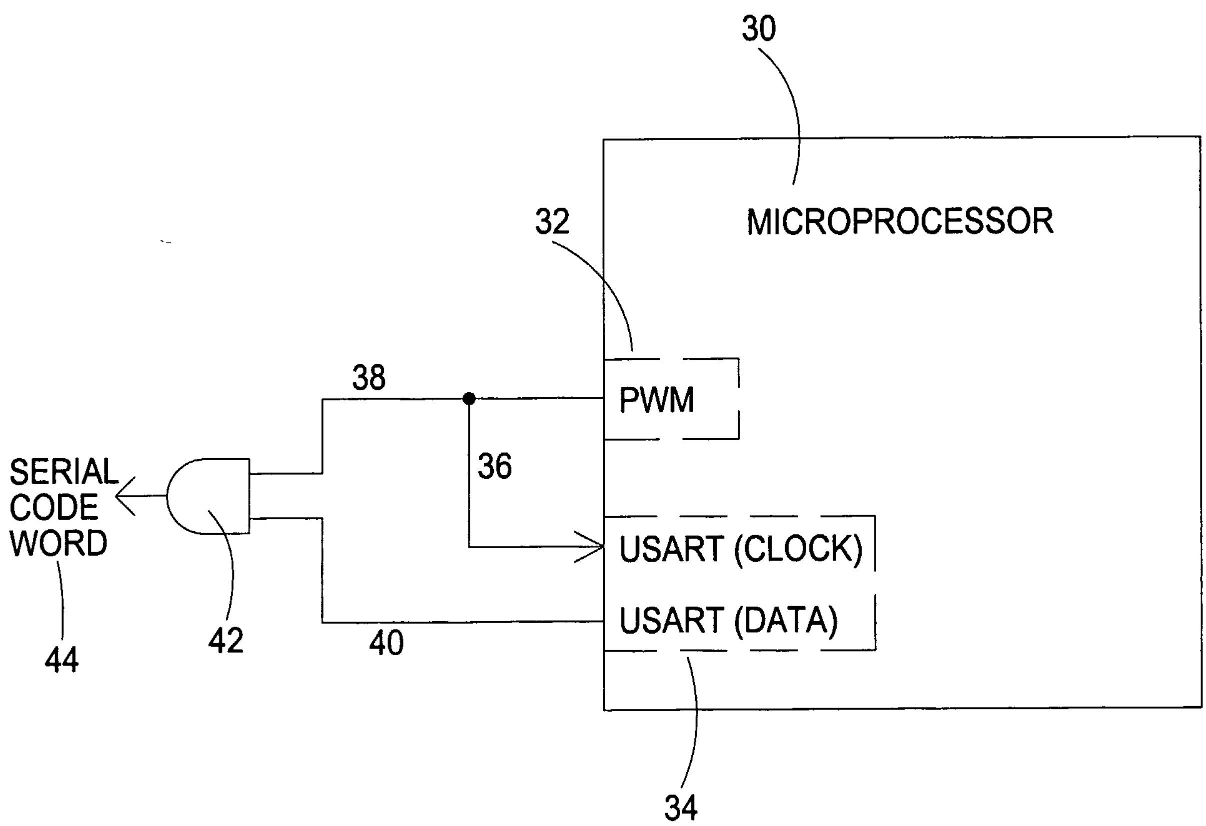

Fig 3

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01B7/00 G01D3/08 G08C23/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01B G01D G08C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 337 669 A (RENISHAW PLC) 18 October 1989 (1989-10-18) cited in the application abstract; claims	1,4,5
Y	US 6 118 567 A (ALAMEH RACHID M ET AL) 12 September 2000 (2000-09-12) column 1, line 65 -column 2, line 13; figures 2,3 column 4, line 46 -column 5, line 18	1,4,5
A	GB 2 137 457 A (ARUGA MASAHIRO) 3 October 1984 (1984-10-03) abstract; figures 2,3	2,3

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lloyd, P

INTERNATIONAL SEARCH REPORT

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Patent document cited in search report		Publication date	Patent family member(s)			Publication date
EP 0337669	A	18-10-1989	DE	68916463	D1	04-08-1994
			DE	68916463	T2	17-11-1994
			EP	0337669	A2	18-10-1989
			JP	2021794	A	24-01-1990
			JP	2994401	B2	27-12-1999
			US	5150529	A	29-09-1992
			EP	0337670	A2	18-10-1989
			JP	2015733	A	19-01-1990
US 6118567	A	12-09-2000	NONE			
GB 2137457	A	03-10-1984	JP	59223908	A	15-12-1984
			US	4609951	A	02-09-1986