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(54) Commodity metering systems.

(57) A commodity metering system, particularly for metering electricity, comprises a credit meter having an optical port via which it can be reprogrammed and its readings of the amount of the commodity supplied can be accessed. To convert the meter into a prepayment metering system, a separate prepayment unit is connected to it by means of an optical link which is sealingly coupled to the optical port of the meter. The prepayment unit stores credit read from credit tokens, typically in the form of electronic keys, smart cards or magnetic cards, and periodically reads the meter via the optical link. When the monetary value of the amount of the commodity supplied equals the value of the credit stored, the prepayment unit cuts off the supply of the commodity. The prepayment unit also has an optical port, which communicates via the optical link with the optical port of the meter and via which the meter readings can be accessed and both the meter and the prepayment unit can be reprogrammed.

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COMMODITY METERING SYSTEMS

This invention relates to commodity metering systems, and is more particularly but not exclusively concerned with electricity metering systems which can be arranged to operate as prepayment systems.

At the present time, many domestic electricity consumers are provided with a credit electricity meter, that is a meter which measures the amount of electricity they consume, and which is periodically read by the electricity supplier so that a bill for the electricity consumed can be prepared and sent to the consumer. However, in some circumstances, e.g. in premises where the consumers change fairly frequently, or for consumers who are a bad credit risk, the electricity supplier prefers to provide a prepayment electricity meter, that is a meter into which a token (e.g.a magnetic card or an electronic key), paid for in advance, has to be inserted to secure a supply of electricity.

With current designs of electricity meters, a given consumer usually has one kind of meter or the other, and it is difficult and expensive to change between them. It is an object of the present invention to alleviate this problem.

According to the present invention, there is provided a commodity metering system comprising a commodity meter connected to meter a supply of a commodity to a consumer and having an optical port via which the measurements made by the meter can be accessed, and a separate prepayment unit comprising an optical link communicating with the optical port of the meter, means for accepting prepayment tokens, a circuit responsive to accepted prepayment tokens and the measurements accessed via the optical link to interrupt the supply of the commodity to the consumer once an amount of the commodity authorized by one or more accepted tokens has been supplied, and an optical port communicating via the optical link with the optical port of the meter, whereby the measurements made by the meter can be accessed via the optical port of the prepayment unit.

Thus in the system of the present invention, the meter, which may typically be a programmable credit electricity meter, has been relatively easily converted into a prepayment meter by the addition of the separate prepayment unit, but can readily be converted back to a credit metering system by removal of the prepayment unit. However, with the prepayment unit in place, the meter can still be interrogated and programmed, by coupling a standard optical interrogation and programming device to the optical port of the prepayment unit.

Preferably the optical link is connected to the optical port of the meter by a sealed connection, that is a connection which is sealed by the supplier so that disconnection and/or tampering therewith is readily apparent.

Advantageously, the system includes means for interrupting the supply of the commodity in response to unauthorized disconnection of the optical link.

The supply of the commodity may be interrupted by means within the prepayment unit and/or by means within the meter.

The optical link preferably comprises an optical head which couples to the optical port of the meter and which comprises at least one light emitting device for directing light into the optical port, at least one light responsive device for receiving light from the optical port, and an electrical lead connecting said devices to the prepayment unit.

The invention also comprises a prepayment unit of the kind described in the principal statement of invention, adapted for connection to a meter having an optical port via which its measurements can be accessed.

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which :

Figure 1 is a block-circuit diagram of a first part of an electricity metering system in accordance with the present invention;and

Figure 2 is a block circuit diagram of a further part of the system of Figure 1.

The part of the electricity metering system in accordance with the present invention shown in Figure 1 consists principally of a twin-element, multi-rate, optically readable and programmable credit electricity meter, which is indicated generally at 10 . The meter 10 comprises a housing 12 containing a live input terminal 14 connected to a live input wire 16 of an AC electricity power distribution network, whose neutral and earth wires have been omitted from the drawing for the sake of simplicity. The live input terminal 14 is connected via a first measurement shunt 18 to a first live output terminal 20, and via a second measurement shunt 22 and a contactor 24 in series to a second live output terminal 26.

The two shunts 18 and 22 are responsible for the designation of the meter 10 as a "twin-element" meter, and it will be appreciated that the meter provides two separate metered electricity supplies, an unswitched one at the live output terminal 20 and a switchable one at the live output terminal 26, the switchable supply typically being available at off-peak hours only.

The shunts 18 and 22 are directly connected to respective solid state meter circuits 30, 32 of the

kind disclosed in United Kingdom Patent No. 1 603 648, providing the Circuits with input signals representative of the respective currents flowing to the live output terminals 20 and 26. As described in UK Patent No. 1 603 648, the circuits 30, 32 also receive respective input signals representative of the voltage between the live and neutral wires, and multiply their respective input signals together to produce respective output signals representative of the power being supplied to the terminals 20 and 26 respectively. These two power-representative output signals a re supplied to respective inputs of a microcomputer 34.

The microcomputer 34 comprises in known manner a central processing unit (CPU) 36, a read only memory (ROM) 38 containing its program, and a random access memory (RAM) 40 in which it accumulates, inter alia, the power representative output signals produced by the metering circuits 30, 32 in locations corresponding to times of day at which different charging rates (or tariffs) apply, and an output which closes the contactor 24 for one or more selected time periods per day. The times of day at which the different charging rates or tariffs begin and end, and at which the contactor 24 is to be opened and closed, are also stored in the RAM 40. Current or actual time of day information is provided by a 50Hz or 60Hz clock signal derived from the electricity distribution network, with battery back-up (not shown) for maintaining timing information in the event of power outage, and/or from a radio teleswitch (not shown) of the kind described in the United Kingdom Patent No. 2 070 897. In the latter case, not only can the time of day information in the microcomputer 34 be periodically corrected by broadcast radio signals (ie the microcomputer can have its "internal clock" periodically reset to the correct time of day), but also the times of day at which the various tariffs apply and at which the contactor 24 opens and closes can be reprogrammed by broadcast radio signals.

The microcomputer 34 further comprises, again in known manner, a display driver 42 for driving a liquid crystal display (LCD) 44, and inputs for receiving input signals from push buttons 46 which can be used to cause the display 44 to display the stored energy readings constituted by the accumulated power representative signals mentioned earlier in a predetermined sequence.

In addition, the microcomputer 34 has an interrupt port 48 at which it receives the aforementioned 50Hz or 60Hz clock signal and power fails and reset signals from a power fail watchdog circuit 50, an output connected to apply a watchdog confirm signal to an input of the watchdog circuit from time to time, to confirm its continued operative status, as well as respective inputs and outputs coupled to a non-volatile memory 52 in the form of an EEPROM. Upon detection of the onset of a power outage, the watchdog circuit 50 causes the microcomputer 34 to transfer the readings and time-of-day information stored in its RAM 40 into the EEPROM 52. Additionally, at the end of a power outage, the watchdog circuit 50 initiates the transfer of the information saved in the EEPROM 52 back into the RAM 40.

Finally, the microcomputer 34 is provided with a serial input/output port 54, which is coupled to a ZVEI optical port 56 provided in the housing 12 of the meter 10. The optical port 56 includes a light emitting device 58 in the form of a light emitting diode (LED), and a light responsive device 60 in the form of a photodetector, which are respectively positioned to direct light outwardly through and receive light via a window 61 sealed into the housing 12 of the meter 10.

The meter 10 as described so far is of known (albeit rather sophisticated) form, and used alone constitutes a credit meter. It can be programmed and/or read by a hand-held optical device (not shown) which is held in registration with the optical port 56. The hand-held device includes a ZVEI lead comprising light emitting and light responsive devices which co-operate with the devices 60 and 58 respectively, to send serial signals to and receive serial signals from the microcomputer 34. This enables new times of day, stored in non-volatile memory in the hand-held device, to be entered into the RAM 40, and/or permits meter readings stored in the RAM 40 to be read out into the non-volatile memory in the hand-held device.

However, the present invention enables the credit meter 10 to be converted into a prepayment meter, simply by sealingly coupling a prepayment unit in accordance with the present invention to its optical port 56 by means of an optical link. Such an optical link is indicated at 62 in Figure 1, while such a prepayment unit is indicated at 64 in Figure 2.

The optical link 62 comprises a ZVEI head 66, which is sealingly coupled to the optical port 56 of the meter 10. The head 66 includes a light emitting device 68 in the form of an LED, and a light responsive device 70 in the form of a photodetector, positioned to co-operate with the devices 60 and 58 respectively. The devices 68, 70 in the head 66 are coupled via an electrical lead 72 constituting a two way serial link to the prepayment unit 64 of Figure 2.

The prepayment unit 64 comprises a housing 72 containing a live input terminal 74, which is externally connected to receive the metered but unswitched electricity supply available at the live output terminal 20 of the meter 10. The live output terminal 74 is connected via a contactor 76 to a live output terminal 78, thus converting the un-

switched supply from the meter 10 into a switchable supply.

The prepayment unit 64 also includes a microcomputer 80, which is basically similar to the microcomputer 34 of the meter 10. Thus the microcomputer 80 comprises a CPU 82, a ROM 84, and RAM 86, an output which operates the contactor 76, a display driver 88 coupled to an LCD 90, inputs coupled to push buttons 92, an interrupt port 94 coupled to receive a 50Hz or 60Hz clock signal and to a power fail watchdog circuit 96, and inputs and outputs coupled to an EEPROM 98. However, it has two serial input/output ports 100 and 102, the former being connected to the devices 68, 70 in the lead 66 via the electrical lead 72 and the latter being connected to a ZVEI optical port 104 identical to the port 56 in the meter 10. Additionally, it has inputs and outputs coupled to an electronic token interface 106, which comprises circuitry for co-operating with electronic prepayment tokens : such circuitry and tokens are described in our United Kingdom Patents Nos. 2 153 573, 2 191 622, 2 191 883 and 2 225 471 (although the tokens can be magnetic cards rather than keys containing EEPROMs if desired). Finally, it has a further output connected to a buzzer 108.

The installation of the prepayment unit 64 is typically carried out by a member of the electricity supplier's service personnel, who, having sealingly connected the head 66 to the port 56 of the meter 10, programs both the prepayment unit 64 and the meter 10 with a hand-held device of the kind mentioned earlier, applied to the optical port 104 of the prepayment unit.

The programming of the meter 10 is achieved via the microcomputer 80, which is itself programmed to route appropriately addressed signals from the hand-held unit via the optical link 62 to the optical port 56 of the meter 10. One of the onwardly routed programming signals sets a particular bit in the RAM 40 of the microcomputer 34 to indicate to the microcomputer 34 that a prepayment unit is coupled to the optical port 56 of the meter 10, ie it tells the meter 10 that it is no longer a credit meter, but now forms part of a prepayment meter. Other onwardly routed programming signals, if required, update the various times of day stored in the RAM 40 to define the various tariff periods and switching times of the contactor 24.

The prepayment unit 64 is programmed with information concerning the price per unit of energy for each of the various tariff periods of the meter 10, as well as debt recovery information if appropriate (ie if the consumer in whose premises the meter 10 is installed already owes money to the electricity supplier, the amount and rate of recovery are entered). All this information is stored in the RAM 86, but can be transferred to and from the EEPROM 98 in the event of a power outage, as described earlier in relation to meter 10.

In operation, the consumer purchases credit from the electricity supplier, which credit is stored electronically or magnetically in an electronic key, smart card or like prepayment token, and then entered into the prepayment unit 64 via the electronic token interface 106, e.g. as described in the aforementioned United Kingdom Patent No. 2 153 573. The buzzer 108 assists in the credit entering process, by providing an audible signal when credit is validly entered and accepted, and a different audible signal if credit is not validly entered or accepted (e.g because the token is an already used one, or is damaged in some way).

The prepayment unit 64 interrogates the meter 10 at regular intervals, readings the various energy consumption reading contained in the RAM 40 of the microcomputer 34 in the meter. into the RAM 86 of the microcomputer 80 in the prepayment unit. Upon each such reading, the microcomputer 80 calculates how much credit is left, and when the credit is exhausted, opens the contactor 76. At this point, the prepayment unit 64 stops interrogating the meter 10, which, in the absence of receiving interrogation signals for a predetermined period of time, opens its own contactor 24. The consumer's supply of electricity is therefore completely cut-off. However, to prevent hardship, one of the push buttons 92 is effective to call up a predetermined amount of emergency credit (to be recovered, or paid for, out of the credit in the next token to be inserted in the prepayment unit 64). Additionally, and again to prevent undue hardship, if credit becomes exhausted near the start of the warm-up period of storage heating, the microcomputer 80 can be arranged not to interrupt the electricity supply until the warm-up period is completed.

It will be noted that the prepayment unit 64 does not write information to the meter 10 in normal operation : it merely interrogates (or reads) the meter. This has the advantage of minimizing the possibility of corruption of the information stored in the meter 10, and enabling the prepayment unit 64 to be used with meters of different manufacture as long as they use a common format for storing their readings.

It will also be noted that the method of telling the meter 10 that credit is exhausted, viz the cessation of interrogation signals from the prepayment unit 64, has the advantage that unauthorized removal or breakage of the optical link 62 produces the same effect at the meter 10 as credit exhaustion, so that the meter 10 opens its contactor 24. The prepayment unit 64 is programmed such that if it is unable to interrogate the meter 10 because the optical link 62 has been removed or broken, it opens its contactor 76.

Many modifications can be made to the described embodiment of the invention. For example, the devices 68 and 70 can be disposed inside the prepayment unit 64, with the electrical lead 72 being replaced by an optical fibre coupling for conveying the optical signals produced by the devices 58 and 68 to the devices 70 and 60.

Although the invention has been described with reference to the electricity metering system, it is also applicable to the metering of other commodities, such as water and gas. In those cases, the water and gas meters involved are preferably electronic, but this is not strictly necessary, as it is possible to envisage water and gas meters in which the positions of movable indicator discs or wheels displaying the readings of the meters are optically readable by a suitable optical read head (e.g. a parallel rather than serial read head) using light emitting and sensing devices similar to the devices 68 and 70 to direct light to and sense light reflected from the indicator discs or wheels.

Claims

1. A commodity metering system comprising a commodity meter connected to meter a supply of a commodity to a consumer and having an optical port via which the measurements made by the meter can be accessed, and a separate prepayment unit comprising an optical link communicating with the optical port of the meter, means for accepting prepayment tokens, a circuit responsive to accepted prepayment tokens and the measurements accessed via the optical link to interrupt the supply of the commodity to the consumer once an amount of the commodity authorized by one or more accepted tokens has been supplied, and an optical port communicating via the optical link with the optical port of the meter, whereby the measurements made by the meter can be accessed via the optical port of the prepayment unit.

2. A system as claimed in claim 1, wherein the optical link is connected to the optical port of the meter by a sealed connection.

3. A system as claimed in claim 1 or claim 2, further including means for interrupting the supply of the commodity in response to unauthorized disconnection of the optical link.

4. A system as claimed in any preceding claim, wherein the prepayment unit is arranged to access the meter measurements periodically, and to calculate after each such access, on the basis of price information stored in the prepayment unit, the amount of credit remaining.

5. A system as claimed in claim 3 and claim 4, wherein at least part of the interrupting means is in the meter, and is arranged to interrupt the commodity supply controlled thereby if the meter detects that the prepayment unit has failed to access the meter measurements for a predetermined amount of time.

6. A system as claimed in claim 3 and claim 4, wherein at least part of the interrupting means is in the prepayment unit, and is arranged to interrupt the commodity supply controlled hereby if the prepayment unit fails to access the meter measurements for a predetermined amount of time.

7. A system as claimed in any one of claims 1 to 4, wherein the supply of the commodity is interrupted by means within the prepayment unit and/or by means within the meter.

8. A system as claimed in any preceding claim, wherein the optical link comprises an optical head which couples to the optical port of the meter and which comprises at least one light emitting device for directing light into the optical port, at least one light responsive device for receiving light from the optical port, and an electrical lead connecting said devices to the prepayment unit.

9. A prepayment unit for use with a commodity meter connected to meter a supply of a commodity to a consumer and having an optical port via which the measurements made by the meter can be accessed, the prepayment unit comprising an optical link communicating with the optical port of the meter, means for accepting prepayment tokens, a circuit responsive to accepted prepayment tokens and the measurements accessed via the optical link to interrupt the supply of the commodity to the consumer once an amount of the commodity authorized by one or more accepted tokens has been supplied, and an optical port communicating via the optical link with the optical port of the meter, whereby the measurements made by the meter can be accessed via the optical port of the prepayment unit.

10. A unit as claimed in claim 9, further including means for interrupting the supply of the commodity in response to unauthorized disconnection of the optical link.

11. A unit as claimed in claim 8 or claim 9., wherein the prepayment unit is arranged to access the meter measurements periodically, and to calculate after each such access, on the basis of price information stored in the prepayment unit, the amount of credit remaining.

12. A unit as claimed in claim 10 and claim 11, wherein at least part of the interrupting means is in the prepayment unit, and is arranged to interrupt the commodity supply controlled hereby if the prepayment unit fails to access the meter measurements for a predetermined amount of time.

13. A unit as claimed in any one of claims 9 to 12, wherein the optical link comprises an optical head which couples to the optical port of the meter and

which comprises at least one light emitting device for directing light into the optical port, at least one light responsive device for receiving light from the optical port, and an electrical lead connecting said devices to the prepayment unit

Fig.1

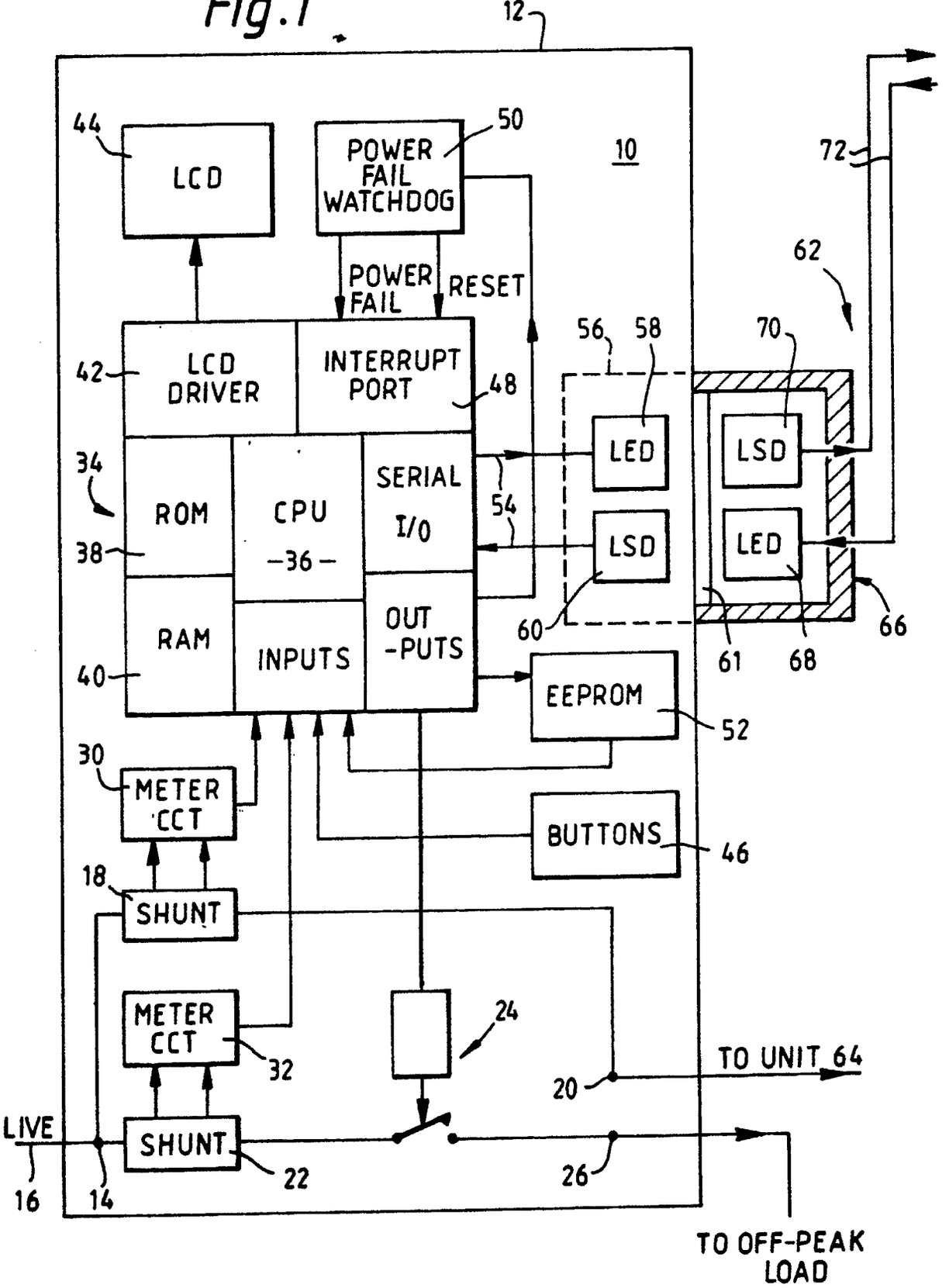
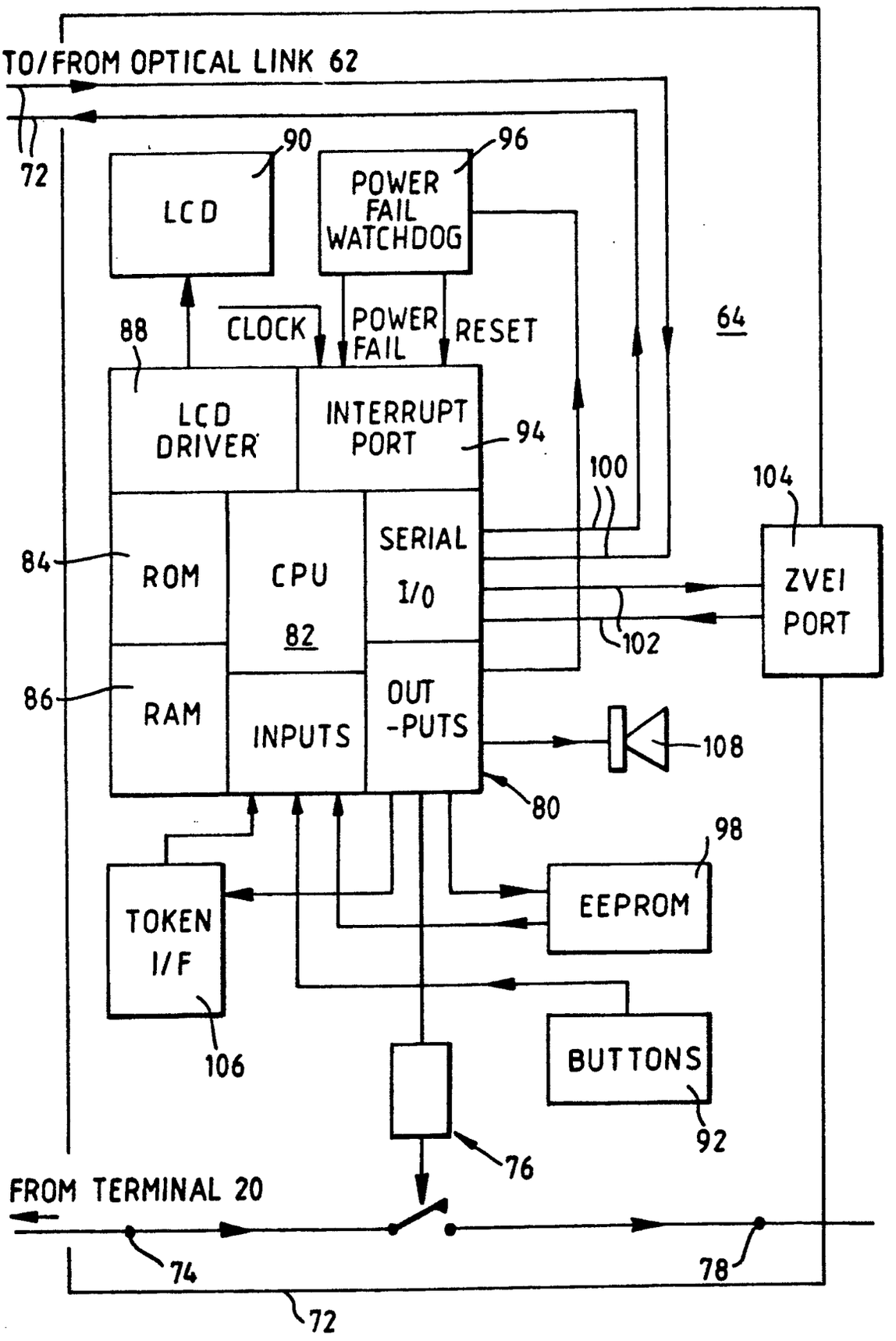

12
10
44
LCD
50
POWER FAIL WATCHDOG
72
62
POWER FAIL
RESET
56
58
70
42
LCD DRIVER
INTERRUPT PORT
48
LED
LSD
34
ROM
CPU -36-
SERIAL I/O
54
LSD
LED
38
RAM
INPUTS
OUT -PUTS
60
61
68
66
40
EEPROM
52
30
METER CCT
BUTTONS
46
18
SHUNT
METER CCT
32
24
TO UNIT 64
20
LIVE
SHUNT
22
26
16
14
TO OFF-PEAK LOAD

Fig. 2


TO/FROM OPTICAL LINK 62
72
LCD
90
POWER FAIL WATCHDOG
96
64
88
CLOCK
POWER FAIL
RESET
LCD DRIVER
INTERRUPT PORT
94
100
104
84
ROM
CPU 82
SERIAL I/O
ZVEI PORT
102
86
RAM
INPUTS
OUT -PUTS
108
80
98
TOKEN I/F
EEPROM
106
BUTTONS
92
76
FROM TERMINAL 20
74
78
72

European Patent Office

EUROPEAN SEARCH REPORT

Application Number EP 90309892.9

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
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A	--	2,8,13	
D,Y	GB - A - 2 191 622 (SCHLUMBERGER ELECTRONICS) * Totality *	1,9	
A	-- FR - A - 2 548 803 (THOMSON CSF) * Totality *	1,9	
A	-- GB - A - 2 102 169 (GROUP NH LIMITED) * Totality *	1,9	
A	-- GB - A - 2 062 324 (CECIL ALBERT TOLL) * Totality *	1,9	
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D,A	-- GB - A - 2 191 883 (SCHLUMBERGER ELECTRONICS) * Totality *	1,9	
D,A	-- GB - A - 1 603 648 (ENERTEC) * Totality *	1,9	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	13-12-1990	BEHMER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90309892.9

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
	LIMITED) * Totality * ----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)

The present search report has been drawn up for all claims

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VIENNA	13-12-1990	BEHMER

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