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(54) Title: SIGNALLING SYSTEM BASED ON INDUCTIVE POWER/SIGNAL TRANSFER

(57) Abstract

A combination of (1) inductive power distribution to a plurality of stations, (2) data interchange using the inductively powered loop between any addressable station and a controller, and (3) physical arrangement of the stations about an area provides a signalling system. An example embodiment is as an automated pick system for a warehouse; another is for billboards or travellers' destination signs. A preferred system drives up to 500 warehouse bin modules with a 33V, 20 kHz sine wave supply through a loop, up to 100 metres in length, placed along a line of bins. Some stations may include barcode readers; others include infra–red links, but the majority include lamps energisable to attract a picker to various bins around the warehouse and a button to record that the picker has completed collection from that bin.

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SIGNALLING SYSTEM BASED ON INDUCTIVE POWER/ SIGNAL TRANSFER

FIELD

This invention relates to a signalling system and/or an information display and input system having separately addressable signals or lights distributed over an area, capable of being remotely activated by software at different places and at different times.

BACKGROUND

Prior-art light directed paper-free or documentless picking systems in warehouses attempt to direct operators in an optimal sequence to the location of each item in an inventory using light signals. For example a person collecting things for a particular order would identify the order to a controller, which lights a lamp beside a first bin. When the person has completed collection at that bin they press an "OK" button and the light beside the next bin is energised. Electronically transmitted picking information may be sent to one or more operators and in return, real-time picking information such as failure to complete the order from the operators, may provide means for the control and verification of the entire process.

One such approach has been to provide electrically connected stations at each of the locations where the appropriate picking actions may be performed. One type of station, hereafter referred to as a "picking interface module", is located at each item inventory location of which there are typically a plurality. The picking interface modules typically perform the light signalling and picking information display and input described above for each of many assigned inventory items. For the picking interface modules to function as intended each module must be located at the correct item inventory location so that that picking interface module can action the picking of that item. Other types of stations may perform functions associated with the control and verification of

the picking process, for example barcode scanning. Each station is typically electrically terminated to a number of electrically conductive pathways that supply power to the picking interface module and provide data communications to and from a control computer. Such an approach is not satisfactory as the electrical termination and resulting physical connection of the stations to a number of electrically conductive pathways is an undesirable constraint that restricts the movement of the stations and therefore the flexibility of the system. Installation of the apparatus and any subsequent reconfiguration thereafter is difficult and complex due to the number of electrical connections that must be terminated and maintained during the working life of the system.

Each physical electrical termination between a station and an electrically conductive pathway has a probability of failure over time perhaps due to chemical reactions between the material of the electrically conductive termination and its environment. This will result in the failure of the system to operate as intended.

The physical electrical termination or connection between the station and a conductive pathway may also be physically disconnected due to an amount of physical movement between the station and the electrically conductive pathways. This will result in the failure of the system to operate as intended. Disconnection of one station may result in interruption of the signal to the remainder of stations along a communications line, if they are series-connected; or if a "star" connection system is used, the amount of cabling becomes unfeasible, or if many stations are to be connected in parallel across conductors the division of power and data through many channels given a limited source capacity may become excessive.

Because the stations are connected to one or more electrically conductive pathways by termination points they cannot be easily moved from that location on the pathway to another location unless it has termination points. This is an undesirable constraint on the system.

GLOSSARY

Batch Based Picking	This is a method of picking where by a picker picks all the items for one or more totes in a single pass through the picking area. Pickers may pick from the same area concurrently.
Bin	The storage location/container in which a product is stored for order picking in the warehouse. Its most important attributes are its location and the product it contains.
Bulk Storage	The area in a warehouse where stock is stored in bulk to meet anticipated demand, and to act as "safety stock", to cover the lead-time required to procure new stock.
IPDLT	We refer to the technology of our invention as "Induction Power, Data and Locator Technology" or "IPDLT" for short.
Paperless Picking	Any system that eliminates the need for orders to be picked from the information on a paper document. With paperless picking the picker is provided with a user interface that communicates picking information directly between a computer system responsible for the picking of orders and the picker.
Pick	The action of picking a product. A pick represents the actual quantity of an item to pick and where it is picked. (see also Short Pick)
Picker	The person who is responsible for picking an order from the physical warehouse inventory.
Picking Area	An area in a warehouse designed for the rapid picking of items to fulfil orders. (see also Bulk Storage)
Pick to Light	A system whereby the picker is guided (generally in a

	determined sequence) to the picking locations by series of flashing lights.
Shipper	The container an order is dispatched to the customer in. One order may have one or more shippers. It usually has a shipping label attached with delivery and freighting information.
Short Pick	An exceptional case of a pick where the quantity that can be supplied is less than the quantity ordered; the worst case being out of stock completely.
SKU	Short for "Stock-Keeping-Unit". SKU is an identifier for an item that is stored in the warehouse and needs to be tracked in the inventory control system. A SKU is often equivalent to an individual item line, however it may also represent the minimum quantity or "split case" that an item can be ordered in.
Split-case	A unit of quantity that an item is stored or ordered in. (e.g. box of 10 items)
Tote	The container a product is put into in the process of picking items to fulfil an order. The tote may or may not be the same container as the shipper
Zone Based Picking	This is a method of picking where by the Pickers pick in a production line with each picker being responsible for picking items from a defined area or zone within the warehouse. A tote will flow through each zone until it has been completed. (see also Batch Base Picking)

OBJECT

It is an object of this invention to provide an improved signalling system over an area, and/or an information display and input system, or one which will at least provide the public with a useful choice.

STATEMENT OF INVENTION

In one aspect the invention provides a signalling apparatus comprising a primary inductive pathway connected to a power supply capable of supplying inductive power to the pathway, and also connected to means for supplying information through the pathway to a plurality of signal stations.

Preferably each signal station comprises an inductive pick-up connected to signal means the signal station being capable of receiving power and information from the primary inductive pathway.

Preferably each signal station has at least one visual information display means capable of displaying information at a station in response to signal information transmitted along the primary inductive pathway.

Signalling apparatus as previously described in this section wherein some or all of the signal stations include means to transmit as well as receive information.

Signalling apparatus as previously described in this section wherein each signal station has means to transmit information along the primary inductive pathway.

Signalling apparatus as previously described in this section wherein the primary inductive pathway comprises a closed loop having two substantially parallel arms connected together at the end remote from the power supply, and the power supply is a constant current induction power supply.

Signalling apparatus as previously described in this section wherein each station has a shaped inductive pick-up capable of fitting onto one arm of the loop of the primary inductive pathway.

Signalling apparatus as previously described in this section wherein each primary inductive pathway has its own loop controller capable of sending and receiving information to or from the signal stations located on that primary inductive pathway.

Signalling apparatus as previously described in this section wherein there is means for electronically determining the location of a particular station.

Signalling apparatus as previously described in this section wherein the means for electronically determining the location of a particular station includes means for timing the difference in arrival time on the different arms of the loop at the loop controller of a pulse transmitted on the loop by a particular station.

In a second broad aspect the invention provides a warehouse having a plurality of picking bins and a signalling apparatus as described above wherein there are a plurality of primary inductive pathways each with its own loop controller, and wherein each picking bin has a signal station associated therewith and each loop controller can communicate with its own signal stations and with a warehouse controller.

In a further preferred aspect the invention provides a signalling system comprising a primary inductive pathway capable of supplying inductive power and communicating information with a plurality of signal stations, each signal station comprising an inductive pick-up connected to signal means capable of receiving power from the primary inductive pathway and communicating information across the primary inductive pathway.

Preferably each signal station has at least one (and more preferably three) lamps, such as light emitting diodes (LEDs), and/or information display device and receiving electronics to switch the LED(s) on or off in response to signal information transmitted along the primary inductive pathway. If LED(s) are used, it may be desirable to use one or more colour changing LED(s) to minimise the size or complexity of each station.

More preferably the primary inductive pathway comprises a closed loop driven as a low power constant current induction system.

In a particularly preferred form of the invention each primary inductive pathway has a length of about 100 metres.

Preferably each station has an inductively coupled pick-up with a low profile formed from a magnetically permeable material capable of fitting onto the primary inductive pathway.

Preferably each primary inductive pathway has its own power supply and its own signal transmitter and receiver.

Preferably the signal is transmitted from a supply to the stations while information is injected onto the loop with a transformer to superimpose the signal information onto the inductive current wave form.

Preferably the or each signal transmitter for a primary inductive pathway is capable of receiving information from a higher-level controller

In another aspect of the invention provides means for electronically determining the physical location of each signal module.

Preferably the means for electronically locating its signal module involves a timed loop signal propagation technique.

In another aspect, the invention provides a cable duct for transmitting information to signal modules. Preferably the cable duct is formed of plastics and it is preferably adapted to receive signal modules, allowing them to be physically locked in place. Preferably the cable duct has two longitudinal ribs each capable of supporting a cable in a fixed physical location relative to the back of the cable duct.

Optionally a single conductive cable is provided for.

In a further aspect the invention provides a signal module capable of being fitted into the preferred signal duct.

Preferably each signal module has a front face and a rear face, with a longitudinal channel on its rear face of such a size and shape that it can snugly fit over the primary inductive pathway in the cable duct.

Preferably the channel has at least one inductive coupling pick up associated therewith.

Preferably the signal module has a microprocessor and a unique assignable identification number associated therewith so that it can in use detect a signal transmitted along the cable duct and operate a visual display means in respect to a particular signal.

More preferably the signal module has means for transmitting an acknowledgment signal along the cable duct back to a control computer.

Preferably a control computer controls the power supply, so that the power supply operates at Extra Low Voltage (ELV), typically less than 50 volts, and more preferably about 33 volts AC, with a current of typically less than 20 amps.

Preferably if the cable length is about 100 metres then the power supply can operate at about 10 amps RMS, or if the cable system extends up to 1000 metres then the power supply could operate at about 33 volts AC with an output current of about 1 amp (RMS).

Preferably each signal module has a capacitor of sufficient size to store enough power to enable it to transmit an acknowledgment signal to the computer control unit.

Preferably the computer control unit will switch off the power supply for a defined interval enabling one or more of the signal modules to transmit information in the dead period of the power supply.

In its most preferred form, the signalling system of this invention is used for a light directed documentless picking system for a warehouse, as previously described in this section. The invention is not however limited to a light directed documentless picking system, but can be used in any application where power is to be transmitted to a plurality of signal stations and information communicated with a plurality of signal stations.

Preferably the system includes means for locating and mapping the position of each module.

PREFERRED EMBODIMENTS

These and other aspects of this invention, which should be considered in all its novel aspects, will become apparent from the following description, which is given by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic overview of an automated, inductively coupled pick system in accordance with the preferred embodiment of this invention.

Figure 2 illustrates the relationship of the primary pathway and an individual pick-up.

Figure 3 illustrates part of the pick-up electronics.

Figure 4 shows a preferred signal module.

Figure 5 shows a preferred cable duct.

Figure 6 shows the preferred module mounted in a cable duct.

Figure 7 illustrates a schematic view of the lay out of the cable ducts and modules associated with picking bins.

Figure 8 is an overview of the power and signal transmission system.

Figure 9 is a circuit diagram showing the computer control of the power supply and signal unit, and the pick up circuit of an individual signal module.

Figure 10 shows the data out circuit to the computer, which would be connected to the output side of the power supply as shown in Figure 9.

Figure 11 is another circuit diagram for a signal module

Figure 12 is a circuit diagram showing how the power loop may be energised and modulated.

Figure 13 is an oscillogram showing the power loop energisation/modulation process.

Figure 14 shows racking (shelves) with ducts running across the front.

Figure 15 shows another configuration of an individual signal module.

Figure 16 shows a duct containing a single inductive conductor.

Figure 17 shows a billboard element as an 8 x 8 matrix of display devices each separately addressable and each capable of changing an optical surface property so displaying an alphanumeric character.

The preferred embodiments to be described below illustrate the solution to the problems previously described; the use of inductive coupling for both the transfer of power and the exchange of data between an IPDLT controller including a power source, using fixed wiring serving as a primary inductive loop that runs past and close to a plurality of active devices (IPDLT Stations) mounted upon or adjacent to individual bins. The IPDLT controller supplies the stations with power. The system provides a data communication protocol between the controller and the stations, and station to station if required. Each IPDLT controller has a network interface to a computer network (any type of network will do) allowing communication with a System Controller.

EXAMPLE - PICK-TO-LIGHT SYSTEMS

The basic pick to light system (as used by a picker) follows this type of process:

1. For each of one or more zones, the picker scans the barcode on the shipping label attached to the tote, so transferring the customer's requirements into the system computer.
2. The system lights up the locations of the items that are to be picked, so that the picker can see from a distance where they are.
3. The system displays the items picking information (item info & quantity to pick) at each lit bin location.
4. The picker proceeds to the location, places the indicated quantity into the tote, and confirms the quantity picked.

5. This process is repeated until the picker has picked all items in his zone, at which point the tote is passed onto the next zone.

Pick-to-Light Apparatus

Here are some examples of different configurations of the apparatus that could be used in a pick-to-light system.

1.3 LED light Panel + Wearable RF terminal + Barcode Scanner

In this version of the system the picker is guided through the order picking process by the 3 LED lamps shown on the example bin module 12A in Fig 4. The picker communicates picks with the system using his wrist terminal. The barcode scanner is used for data collection and verification. The three different colour LEDs are used to control the zones. For example, zones may be staggered in sequence using two of the LEDs, for example; one picker picks according to red lights, while the picker next to him picks in the green zone, and so on. The third light may be used to signal special events such as, bin out of stock, etc. The advent of tricolour LED lamps permits orange, blue, purple, and white (for example) as well, or other means may be employed such as filters to produce coloured lights. Characters may be formed by alphanumeric displays. Flashing codes may also be used (such as the Morse code) in busy or congested warehouses.

2.3 LED light panel with picking interface

In this version the interface used to communicate picking information is included on each light panel. This requires each light panel 12A to have a information display 37, buttons to change the actual quantity that was picked (i.e. short-pick), a button to confirm the actions, and a button to toggle special operations such as undo, set to out of stock etc. The LED lamps shown in Fig 4 may in fact be illuminated press-button switches, or a separate keyboard (see Fig 11) may be used. Input information may again be entered by means of a barcode scanner used by the picker, to identify the tote to be picked to the system, or otherwise.

3. Pick-to-light + Zone based batch picking with battery-powered Wireless Put-to-Tote Lights

This version attaches a wireless (such as infra-red beam 15 or radio frequency) activated battery-powered light to each tote (see 16A, 17A in Fig 1). The totes can now be picked in batches in the zones. This means that a picker can select more than one tote to take through the zone at once. One way of selecting the totes is where the picker selects the number of totes to pick for during one pass through the zone. Another way of selecting the totes is where the system indicates which totes to pick by turning their lights on. The tote lights also make it possible to give the totes priorities based on urgency. A tote could leapfrog the queue as a result of the system turning on its tote light indicating it as being the next to be picked, even though there may be a queue of totes ahead of it waiting to be picked in that zone.

SYSTEM OVERVIEW

In this prototype of an automated pick system (see Fig 1) a warehouse has a supervisory or company host computer 22 connected (typically through a local area network 21 to a system controller computer 20 adapted to manage the warehouse picking system and the stocks. The host would generally create the demands and the system controller would hold information concerning location, number, and so on, capable of responding (for example) to the barcode scans of shipping labels. In turn the system controller communicates with one or more "IPDT" sub-controllers each of which is in control of power generation (13A) for, and communication with (14A) one of a plurality of inductive pathways 10A; each pathway comprising a closed loop formed of an appropriate conductive material. Because this is an inductive system, the conductive material (typically multi-stranded copper) may be coated with a protective and insulating coating. In its most preferred form, each pathway 10A may be up to about 100 metres in length and is capable of providing power and data exchange at a large number of signal station sites along its length. Fig 17 illustrates 64 signal stations.

Along the pathway, there are a number of standard signal stations represented in Fig 1 and in Fig 7 as 12A, 12B, 12C (and later described in more detail as for example in Figs 4, 6, and 11,) on pathway 10A. In practice there may be a very large number (50 to 200) of such stations along each pathway. The precise number depends upon the

user's requirements, and the spacing of different products stored within the warehouse, and electrical limitations although it should be noted that the only signal stations to be in a "high-load" mode would be those having their lamps activated or which are returning data which is normally only a small fraction of the total.

In a warehouse products are typically stored on modular shelving (racking) 1401 as shown in Fig 14, where each shelf 1402 may have a slight slope towards the front and a signal station 12A resides in a visually commanding position usually at the front of each bin. (Of course the nature of the particular product such as weight or temperature constraints will impose restrictions on storage). The inductive pathway 10A which is itself shown in more detail in Fig 5 passes along the front of each shelf and may have a modular connector 1403 for use in making links between shelving modules. (These modular connectors may include test points or the like for maintenance purposes).

In such a system, it is preferable that a signal station has at least one signal means like a light, capable of signalling to an operator that product from that location on the racking should be actioned for picking. In its most preferred form each signal station will have a plurality of lights, of different colours indicating the sequence of the picking operation. Each pathway 10A, 10B, etc is provided with its own power supply 13A; each power supply being adapted to supply inductive power along the pathway and is provided with an associated transceiver 14A capable of receiving information from a system controller 20 and placing it on the inductive loop and also capable of receiving responses from devices (12A, 18A, 19A) supported by the loop. By this means, the system controller 20 can cause the signal stations to switch on or off lights in a particular pattern in order to instruct the operator to follow a particular pick list to ensure that the required number of each items is placed in an appropriate carton or other shipping container.

On occasion, remote access to the warehouse may be required. For example, Internet or dial-up access may be provided to a remote site 25 by means of a preferred firewall 24 to the local area network 21 . The installation company may be 25, where it can provide software support for the system. A purchaser may be able, in a suitably controlled way, to receive product descriptions, view stocks and place an order

according to the principles of "e-business". The warehouse company may transmit information of goods shipped via the software server 25.

It will be appreciated that the above description is but one of many ways in which the system can be operated. Other varieties of module may also be placed on the loop 10A and both communicate through, and draw power from it. One example is a bar-code reader adaptor 18A connectable with a bar-code reader 18. This may be connected through a standard RS-232 serial link as indicated at 1104 in Fig 11. Another example is a local wireless transceiver 19A, which uses beams of infra-red light 15 to communicate with a battery-powered wireless tote station 16A on a bin or open box 16 (shown here on a roller conveyer) or a similar controller 17A on a hand-pushed tote station 17. It will be appreciated that the concept of an inductively powered semi-intelligent device according to this invention can be put into practice in many different ways.

Electronics.

Each primary inductive pathway is preferably a low power inductive power transfer system. Figure 2 illustrates a portion of the primary inductive pathway having a current I flowing within the pathway 10A. A signal station represented schematically by 12A and the inductive linkage is represented by the circle 17.

Figure 3 illustrates principles of the pick-up electronics for the signal station 12A, and includes a data filter (around buffer 303) and a rectifier 304 capable of powering the signal station. Preferably the filter capacitor 305 has sufficient storage of charge to provide for the desired level of amplitude of response pulses. This circuit uses a diode 301 and low-pass filter 302 coupled to a buffer 303 as a signal processing unit. (Fig 11 shows more details).

In this embodiment, the invention provides a low power induction system using a constant current technique to provide a single turn primary with enough surrounding flux (Amp-Turns) to power the signal stations and associated receiving electronics. In this prototype the objective was to produce a 100 metre primary inductive pathway with a power supply providing 33 volts AC.

By using 2.5mm^2 copper conduit wire, the resistive voltage drop is:

$$R = \frac{200}{2.5 \times 60} = 1.33 \text{ ohms}$$

In other words a power supply providing 10 amps of current is possible for the current in the current loop system. Much greater voltages than 33 V can be used to drive inductive power transfer systems and so the maximum loop length is not a constraint.

Using three U15 ferrite cores made of 3C8 material (a high permeability material) this gives a low profile pick-up of about 20mm overall size. A core may be an E-shaped core 306 as shown in Fig 8 or may be a simple rod, positioned so that it intercepts the magnetic flux surrounding the energised loop or conductor 10A/30. A core may even be provided with hinged, encircling parts so that when locked in place it forms an annulus around the conductor rather like a current transformer and this provides tighter coupling between the primary inductive conductor and the secondary pickup coil, wound around the core.

Each power supply can be provided with a signal transceiver 14A employing a standardised format and protocol to send data along the inductive loop in a compatible way, such as by modulating the 20 kHz current in the loop. (See Figs 12 and 13). This will also be transferred inductively across the gap to reach the ferrite-cored pickups at the receivers, and can be selectively filtered before rectification as shown in figs 2 and 11. Hence the invention reduces the total number of cables required for power and data to a single loop having no connectors. Each signalling station can simultaneously pick up power and data from the adjacent one of the primary inductive pathways 10A, 10B... to drive its electronics and one or more of the LEDs. By this means, it is possible to provide sufficient power at low voltage to switch on or off a plurality of lights and change information display devices associated with the primary inductive pathway.

The signal information can be used to change the information displayed in response to information transmitted by the signal transmitter 14A, which in general is responsive to information received from the system controller 20. (Items 14A and 20 may of course be the same computer in some installations). Such a system is ideally suited to light

directed documentless picking system, but could also be used in other signalling situations where ease of installation and ease of replacement of each signalling station is required. Note that it is not necessary to provide separate power to each signalling station in the form of batteries, or a power (mains or DC) bus. Transmission of power and information using an ELF 20 kHz AC system as described above can operate over reasonable distances (such as 100 metres) using safe and feasible 33 volts AC at say 10 amps to power a large number of signal stations with their associated electronics and LED signal lights.

Example 1 - Signal Station Module

Each signal station 12a, 12b, 12c from Figure 1 is preferably in the form of a rectangular box as shown in Fig 4, having a U shaped channel 33 within the back face thereof adapted to mate with a primary inductive pathway wire mounted along the front of a shelf, so that each module can be mounted about the wire, which is preferably positioned on a support 45. The return wire of the loop 10A is preferably on the border (44 upon support 43) of the duct as shown. Alternatively both wires of the loop may be more symmetrically disposed within the duct by replicating support 45 and having two channels behind each signal station.

Preferably the duct 20 is moulded from plastics material, and as shown in section in Fig 6 has a bottom 41, two side walls 42, 43 and wire supporting means 43, 45 so that the wires 30, 31 are supported proud of the base 41. Suitable apertures can be drilled in the back of the duct so that it can be secured to the front of a shelf or the like, enabling the modules to be mounted in close proximity to the picking bins.

Each module 12A is preferably of a standard size (at least in section) and is adapted to fit within the duct 20 so that the module can be located at least partly within the duct, with its channel 33 in controlled proximity to the inductive wires 30, 31. The pickup coil and core would typically be located within the module and oriented so that the core entraps an adequate amount of flux.

Preferably each module has fastening means so that it cannot either be moved along the length of the duct, or removed from the duct without use of a special tool. It is envisaged that the duct may be provided with a return (not shown) at the tip of edges

42, 43 to form a spring clip or locking mechanism preventing the release of the module. and that the duct may also be provided with stop means at intervals along its length so that once a module has been inserted into the duct it can be locked in place preventing it from being slid along the duct. It will be appreciated that the physical location of each module relative to the picking bins is important so that a particular module can be identified with a particular picking bin. Figure 6 shows how a module 12A will be situated in the duct, with the wires 30, 31 located in relation to channel at the back of the module. (The module is shown as smaller than the duct, in practice it will fill the width of the duct and be secured in place). There is an inductive pickup device conveniently a ferrite pick up mounted at a position where it can interact with the magnetic fields surrounding the wires, in the rear face of the module surrounding the channel which would normally be situated over the data wire.

Each module preferably has a bar code 35 on the front face as well as some form of interactive devices such as signalling LEDs 36, buttons (1103), optionally a liquid crystal display 37/1102 or a keyboard 1103. It will be appreciated that in general each module will be substantially identical in appearance to any other module, differing only by its serial number indicated on the bar code, and/or a printed number, as well as by an identification number forming part of the module circuit, for example in the memory of a microprocessor situated within the module. It will be possible, although far less preferable to use different versions of modules, because the signalling protocol as described below is based on the assumption that each module has the same type of visual or tactile indicator which can then be initiated by a signal from the command computer. The functional significance of each module is preferably a matter of storing in the controller 20 a lookup table for matching the actual address of the module with a description of the contents of the bin behind it.

Figure 7 is a sectional view showing how the modules could be mounted along ducts, each looped pair of wires being connected to the system power supply as previously described. In operation the flashing lights on a particular module would tell the picker to go to that location. The module may have a liquid crystal display (LCD) indicating the number to be picked, or the quantity could be signalled to the picker by means of a radio frequency data terminal, typically worn on the picker's wrist, indicating the

quantity to be picked for a particular flashing bin or LCD or action button displayed on the unit. It is a relatively simple matter to signal the quantity by means of a radio signal to a radio receiver carried by a particular picker, but the picker still needs to know which bin to pick from, and this is the function of the modules with their lights.

Figure 15 shows another configuration of an individual signal module 1500; this one having a lower visible height more in accordance with prior-art paperless picking stations. An "OK" press-button 1103 is included for use when a picker has completed a pick from the corresponding bin. Lamps 36 are also included.

Figure 16 shows a duct 1600 containing a single inductive conductor 30; for a situation in which the outgoing and return wires of a given loop are not run close together but serve separate stations. This duct could hold the signal module 1500 of Fig 15.

Typically there would be up to 512 modules per 100 metres of cable. Each module is preferably programmed to have its own identification number or address, and will listen out for a data signal having a header identifying that particular signalling module. The physical separation of the modules will depend upon the size of the picking means. In some warehouses picking bins could be up to a metre apart, but in for example in electronics warehouse where the components are small, the centers of the modules would be about 200 millimetres apart.

20 kHz power/signal system

Figures 8, 9 and 10 show more details of the transmission of power and signals to identified modules mounted on an inductive loop. Figure 8 is an overview showing the computer control unit 14A connected to the power unit 13A, which in the present example supplies a 20 kHz sine wave at 33 volts AC at 1 amp (RMS). Signal modules 12A are situated along the loop 10A As shown in Fig 4 each inductively coupled signal module will have three lights, preferably coloured lights for example red, yellow and green mounted on the face, and the back of the module will have an inductive power pick up generally described with reference to Figures 2 and 3.

Preferably the power supply operates at 20 kHz, (although other frequencies may be preferred on account of technical benefits or in order to minimise interference

problems) and is preferably amplitude modulated at 2.4 kilobits (kbits) during signalling to the module.

Preferably the system includes some form of acknowledgment from a module that it is present, has received the necessary information and has commenced displaying the appropriate signal to the picker. It is also desirable that the computer control unit can selectively poll the individual signal modules to check their status, and to allow for remote diagnostic testing of each signal module to ensure that the system is fully functioning. (See later for detection of problems).

Preferably each signal module is capable of receiving an appropriate signal from the computer control unit, and sending a signal back to the computer control unit. This may be achieved in a number of different ways, but we prefer that the computer control unit switches off the power transmission for a brief period of time to allow a signal module to transmit a lower powered signal back to the computer whilst the main power transmission is off. Preferably the computer control unit will switch off the power supply for say 100 milliseconds allowing the identified signal module or modules to send acknowledgments back to the power and signal unit on the same cable, i.e.. the data wire 31 identified as the cable used to transmit information from the control computer to the signal module.

Circuit Diagram

Figure 9 shows a circuit diagram for the power and signal unit capable of receiving data from the computer control unit at 2.4kb via an optoisolator to a microprocessor and a TLC 555 controlling the power supply so that the 30 volt AC output is amplitude modulated based on the computer data. This is transmitted along cable 31 and picked up by one or more of the signal module. Because of space limitations, Figure 9 shows only a single circuit diagram associated with the pick up of a single signal module which has a sufficiently large capacitor that the pick up circuit of the signal module can store enough power to retransmit a signal to the computer control unit during the time that the power supply is switched off for reception.

Operation

1. The 20 kHz power supply at 33 volts AC, modulated at 2.4 kHz is sent down cable 31 to the signal modules. Whilst the power supply is on each of the signal modules will be picking up this power so that capacitors will be fully charged, irrespective of whether or not a signal is being broadcast along the wire 31. Consequently each signal module is powered on whilst the power supply is switched on.

2. The power induced in the pick up core is rectified and stabilised by the zener diode in FET pin 7 of TLC 555 B.

3. The data signal at 2.4 kbits is demodulated by the signal diode IN4148 and 10k/0.022 μF filter for the microprocessor (μP).

4. Each of the signal modules will receive the signal, but, being individually and uniquely identified, only one of them will consider itself to be addressed, and then respond to the signal as only one will have the appropriate identification number (not shown) matching the signal header of the data transmitted from the control computer. Hence only one signal module will have its microprocessor activated; the others will remain dormant.

5. The control computer will now turn off the 20 kHz power supply (as pin 4 on TLC 555A will now be set low) for say 100 milliseconds. During this dead period the inductive pathway would normally be silent, and this allows the microprocessor of the identified signal module to send an acknowledgment signal back to the control computer. By turning off the power supply for say 100 milliseconds, this would allow the identified microprocessor to transmit information.

6. At the end of the power off period, i.e.. at the end of the 100 milliseconds the control computer would turn on the power supply again. After transmitting its signal to the control computer the microprocessor would then switch the signal module circuit to a state enabling it to receive again. This is achieved by disabling TLC 555/A with pin 4 low (so that the circuit is now ready to receive data again).

Data Out to Computer

Figure 10 illustrates the connection between the power and signal unit, and the computer pick up circuit capable of detecting and decoding the signal received from a particular signal module. This circuit is connected via wires to the output side of the power supply and uses an optoisolator to isolate the computer from the power supply. The data signal from the signal module is collected by an inducted power pick up, and is amplified by the op amp, and then filtered so that the data signal is transmitted to the computer via the optoisolator.

We show another circuit diagram 1100 for a signal module in Figure 11. Here, 10A and 12A represent the coupling to the powered loop as previously described. The microprocessor 1101 is powered from a bridge rectifier 1110 which preferably includes a low-pass filter 1108 at its input. Driver devices 1105 (data generator) and 1106 (pulse generator) are powered from the microprocessor according to a protocol, in response to a valid address (for this individual device) and sensible data via the input system 1107 (as previously described in relation to Fig 3). The effect of activation of the driver devices is to send an impulse back to the loop and hence to the master controller for that loop. The microprocessor 1101 is also illustrated with a display 1102 and a keyboard 1103 for local operator's use and also has a serial (RS-232 or the like) interface 1104 for use with a barcode reader, an infra-red local wireless communicator, or the like.

Figure 12 (in conjunction with Fig 13 (which is an oscillogram showing the power loop energisation/modulation process) shows one method by which the power loop may be energised and modulated. It will be appreciated that phase and amplitude modulation, for example, could be used to combine signals and data within the power loop 10A. We are using the quenched pulse train approach at present. The device 1202 is a driver capable, when briefly driven (pulse 1301 in Fig 13) of injecting sufficient power into the resonant loop 10A to causing the loop to carry a sinusoidal waveform substantially at the resonant frequency. The clamp 1203 is enabled (pulse 1302) after a set period and for a set period, so that the circulating resonant current is halted or quenched (1303) in a relatively complete manner. The "set period" becomes the data

bit time 1304 and the length of the data bit (short or long) comprises one binary bit of transmitted information. More preferably, the presence of a quenched period can be considered as a binary "1" and the absence of a quenched period as a "0".

EXAMPLE - PICK-TO-LIGHT SYSTEMS

Physical location

It is preferable that the physical location of each signal module is known to the computer control unit which can then store a map of the location of each signal module and the location of each picking bin. By storing a map of the physical locations (in whatever format, or at least the relationship of the location of the various picking bins one to another) it will be possible for the computer to determine the picking order so that a picker can pick efficiently from bins that are close to one another.

The physical location of the signal modules relative to the bins and relative to one another can be determined in a number of different ways. Conveniently the physical location of a particular signal module on a particular length of ducting is established electronically and signalled to the computer.

When instructed by the IPDLT controller a selected IPDLT station will induce a timed signal pulse onto the primary inductive loop. The signal pulse will propagate outwards along the loop from the point of induction. The first pulse to reach a terminated end on the loop will start a timing mechanism on the IPDLT controller. On receipt of the second pulse this timing mechanism will stop and return the interval between the two pulses. Given that the length of the primary inductive loop is known and the propagation speed of the signal on the wire is known, this timed interval can be used to accurately determine the position of the IPDLT station as a measurement of the distance from the terminated ends of the loop.

The transmission speed in a copper cable is typically about 80% of the speed of light, and preferably should be calibrated for each installation. Calibration can be achieved by sending a pulse down the full length of the echo pulse wire 30, and measuring the time taken for the pulse to return from the terminated end of the wire to the computer control unit. Knowing the physical distance of the wire, which typically would be

installed as a fixed length say 100 metres or 1000 metres depending upon the size of the power supply, then the transmission speed in that particular echo pulse wire can be calculated by the computer. Or, conversely. if the propagation speed is well known the same technique could be used to determine the length of the wire.

In order to receive an echo from a particular signal module mounted in the duct, it is preferable that the transmission along the echo pulse wire is interrupted at the physical location of the identified signal module. This can be achieved in a number of different ways but the most convenient way to do this would be to reverse the position of the signal module so that the pick up channel with its associated ferrite core is placed over the echo pulse wire. By shorting out the pick up circuit, the ferrite core will cause any signal pulse sent along the echo pulse wire to be reflected back to the computer control unit. Conveniently the signal module has a test button which can simply be depressed by the installer when it has been temporarily positioned in the reverse position on the duct, so that the computer can then sense the location of that particular signal module, and preferably send a radio frequency signal to the installer and its data terminal to acknowledge that the location of that unit has been established. In order to record the identity of that signal module, the identity could be established by the installer using a bar code reader to read the identity of the signal module from its front face and transmit that by a radio frequency signal to the control computer at the time that the physical location of the module is being established.

Once the location of a module has been established and recorded by the computer, that module can be returned to the correct position and secured in place. The location of the next module can then be established in the same way; and so on.

Alternatively but less preferably the control unit could poll each module in turn to establish their identity but it is difficult to establish their precise physical location in this way, and it is better to establish their location by the timed signal-pulse loop-propagation locater technique and to use the installer to notify the computer system controller of the identification code of the module. Hence the advantage of a bar code on the front face of the module.

ADVANTAGES

Employment of inductive power transfer has the advantage over prior-art warehouse automated picking systems that metal-to-metal contact is not required. Hence electrical connectors having inherent disadvantages such as cost, reliability, and long-term failure, and the possibility of electric shock (such as to children in supermarkets) are avoided. In some circumstances, the ability to work under adverse environmental conditions such as in high humidities, outside, in marine environments, and the like render an automated warehouse project feasible.The elimination of wiring dramatically improves the flexibility of any system using IPDLT to supply power and data communications to stations. Light directed documentless picking systems using IPDLT can be easily reconfigured by the end user.

IPDLT makes installation faster and less expensive as there is less wiring involved
IPDLT makes the system easier to maintain as signal stations can be easily replaced by the customer without shutting down any part of the system.

IPDLT can be used in flammable environments that require the system to be spark free. IPDLT can also be used in chemically aggressive environments that would quickly degrade electrical connections. IPDLT can be used in environments that are susceptible to short-circuiting such as underwater.

The locator technology automates what would normally be a difficult and human error prone process of physically locating a device on the system

VARIATIONS

In Figure 17 we illustrate one of many possible applications in advertising and communications. This figure shows a billboard element capable of displaying any one character upon the surfaces of an 8 x 8 matrix of display devices, each separately addressable and each capable of changing an optical surface property (such as reflectivity or light emission) so making an alphanumeric character. Of course each

addressable display device might itself comprise a matrix of separately controllable surfaces perhaps even selected from internal lookup tables carrying airport destinations or train leaving times. While the sign is particularly useful for displays which change frequently, it may also be useful for signs and directions in hospitals, in supermarkets(possibly linked to the warehouse application) or for three-dimensional displays.

Other applications might take advantage of the non-contact feature of inductively transferred power, and be used on, in, or near water even sea water while maintaining safe operating conditions. For example, swimming pools, marinas, on boats, in gardens, shellfish farming, underwater (such as for divers), in hazardous environments such as down coal mines. With extra power provision, applications such as runway and taxi strip lights are feasible.

Although the invention has been described with reference to LEDs as the means to signal an operator, it will be appreciated that other visual systems could be used, and in some cases auditory signals could be used, or some combination of both visual and auditory signals.

Although the system has been described with reference to a radio frequency network controller, it will be appreciated that the power supplies could be physically connected to an appropriate system controller.

Finally, various other alterations or modifications may be made to the foregoing without departing from the scope of this invention.Another version of the invention uses an air core to couple the signal module to the primary inductive pathway. An air core uses wires without any magnetically permeable material as a pickup to couple to the inductive pathway.

CLAIMS

1. A signalling apparatus comprising a primary inductive pathway and a power supply for supplying inductive power and means for supplying information to a plurality of signal stations, each signal station comprising an inductive pick-up connected to signal means capable of receiving power and information from the primary inductive pathway.

2. Signalling apparatus as claimed in the preceding claim wherein each signal station has at least one visual information display means capable of displaying information at a station in response to signal information transmitted along the primary inductive pathway.

3. Signalling apparatus as claimed in the preceding claim wherein some or all of the signal stations include means to transmit as well as receive information.

4. Signalling apparatus as claimed in the preceding claim wherein each signal station has means to transmit information along the primary inductive pathway.

5. Signalling apparatus as claimed in the preceding claim wherein the primary inductive pathway comprises a closed loop having two substantially parallel arms connected together at the end remote from the power supply, and the power supply is a constant current induction power supply.

6. Signalling apparatus as claimed in the preceding claim wherein each station has a shaped inductive pick-up capable of fitting onto one arm of the loop of the primary inductive pathway.

7. Signalling apparatus as claimed in the preceding claim wherein each primary inductive pathway has its own loop controller capable of sending and receiving information to or from the signal stations located on that primary inductive pathway.

8. Signalling apparatus as claimed in the preceding claim wherein there is means for electronically determining the location of a particular station.

9. Signalling apparatus as claimed in the preceding claim wherein the means for electronically determining the location of a particular station includes means for

timing the difference in arrival time on the different arms of the loop at the loop controller of a pulse transmitted on the loop by a particular station.

10. A warehouse having a plurality of picking bins and a signalling apparatus as claimed in any one of claims 6 to 9, wherein there are a plurality of primary inductive pathways each with its own loop controller, and wherein each picking bin has a signal station associated therewith and each loop controller can communicate with its own signal stations and with a warehouse controller.

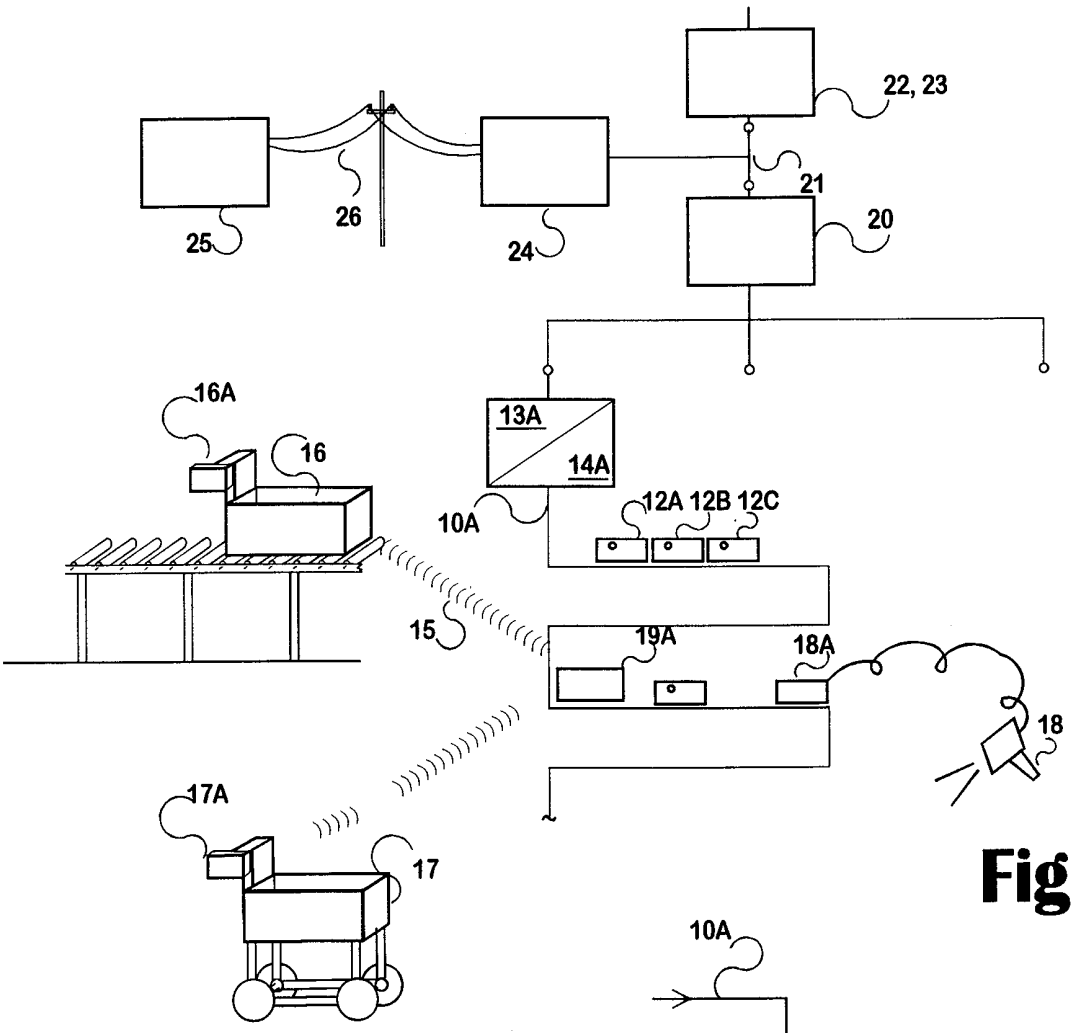


Fig 1

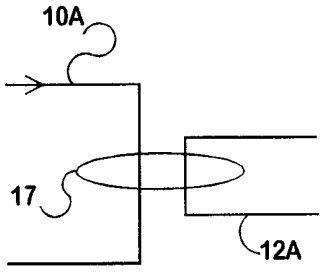


Fig 2

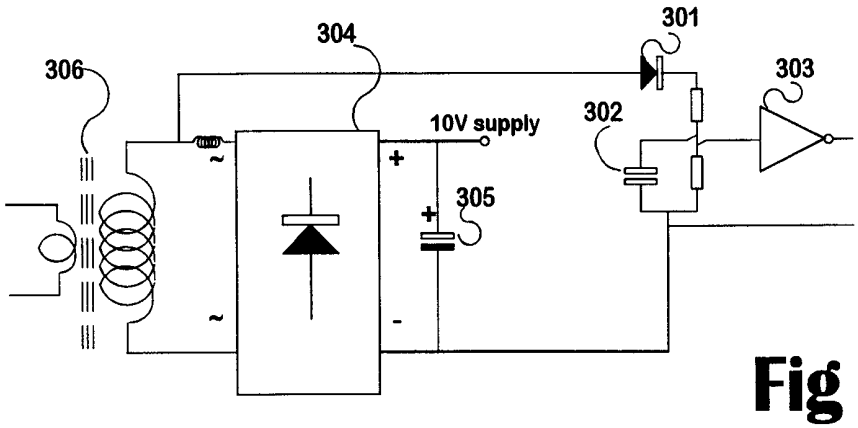


Fig 3

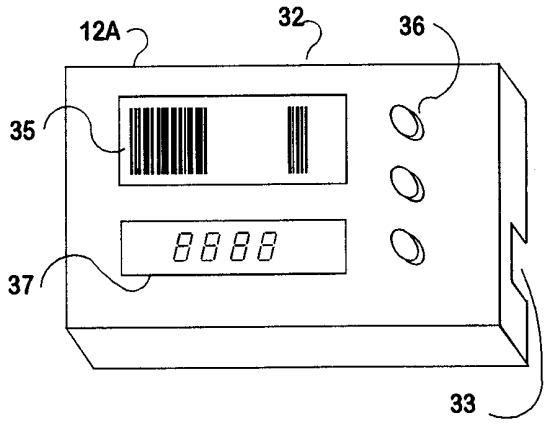


Fig 4

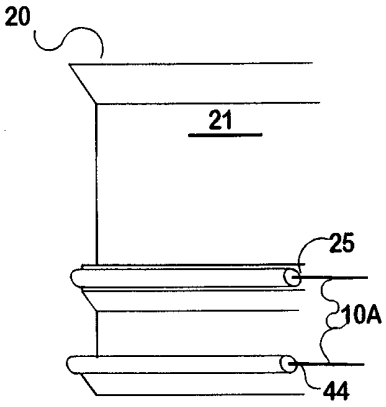


Fig 5

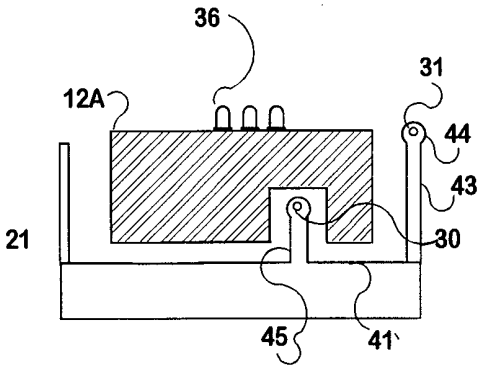


Fig 6

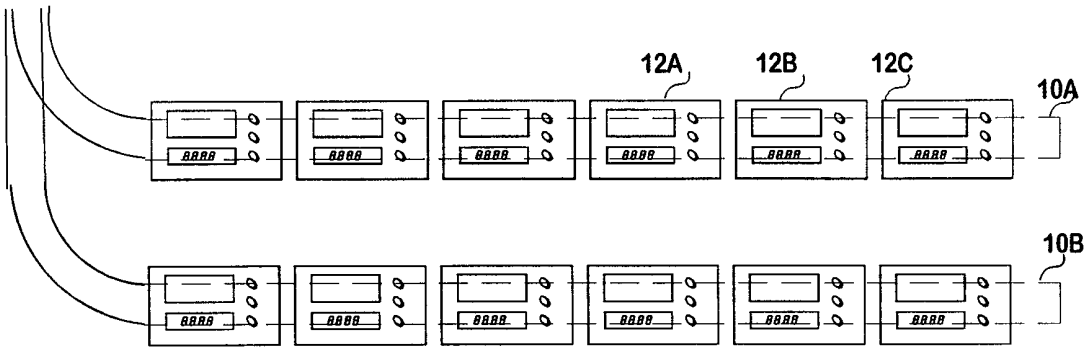


Fig 7

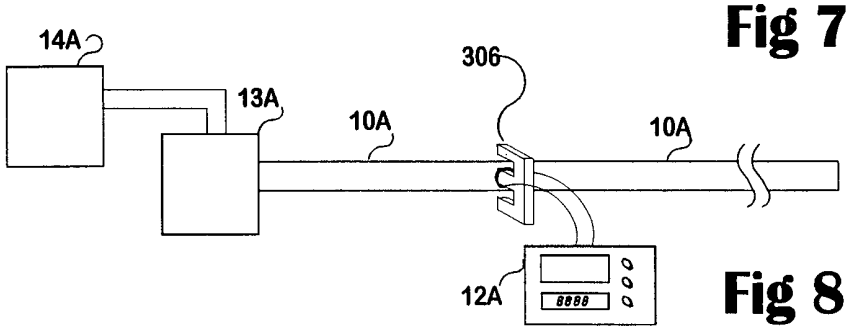


Fig 8

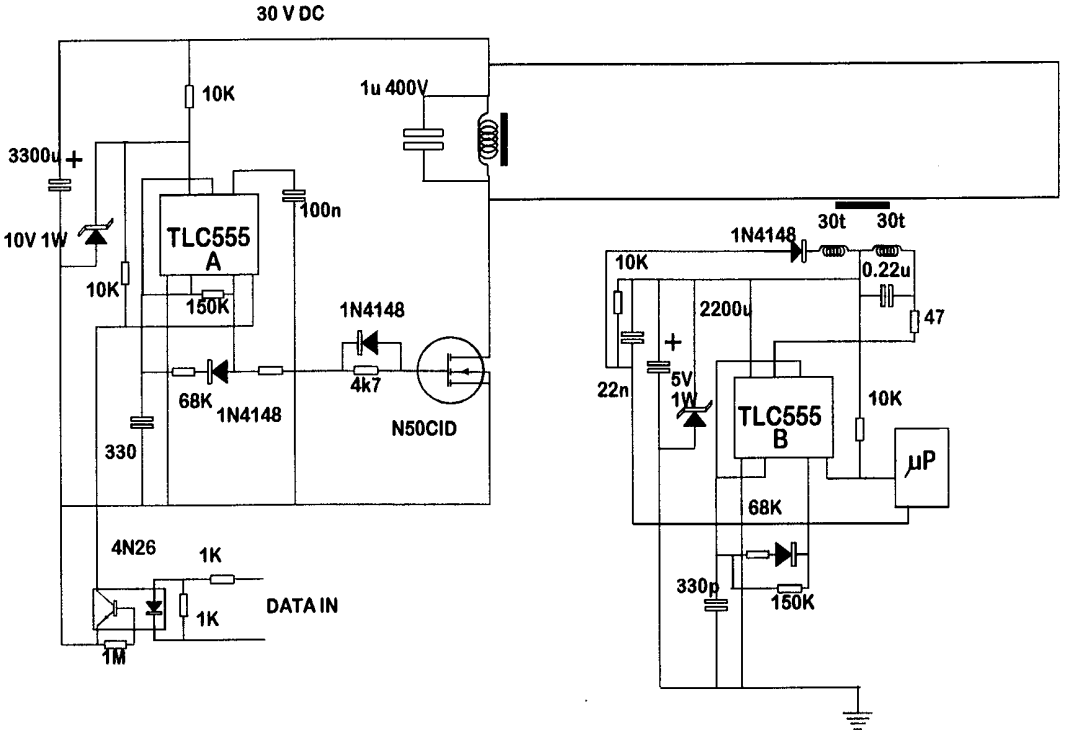

30 V DC
10K
1u 400V
3300u
10V 1W
TLC555 A
100n
10K
150K
1N4148
68K
1N4148
4k7
N50CID
330
4N26
1K
1K
DATA IN
1M
1N4148
30t
30t
10K
0.22u
2200u
47
22n
5V 1W
TLC555 B
10K
µP
68K
330p
150K

Fig 9

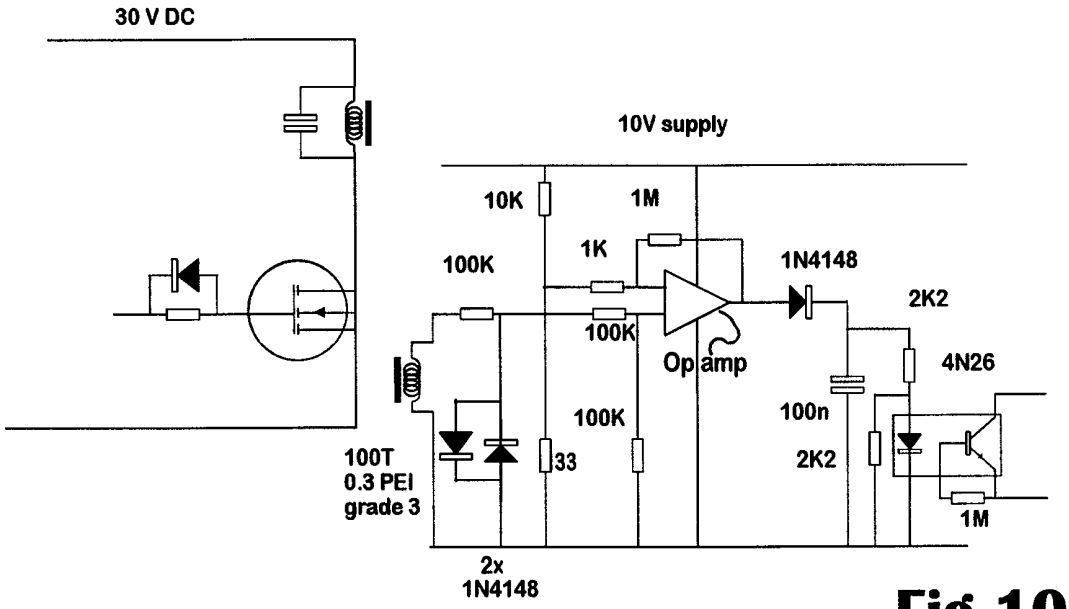

30 V DC
10V supply
10K
1M
1K
100K
1N4148
2K2
100K
Op amp
4N26
100K
100n
100T
0.3 PEI
grade 3
33
2K2
1M
2x
1N4148

Fig 10

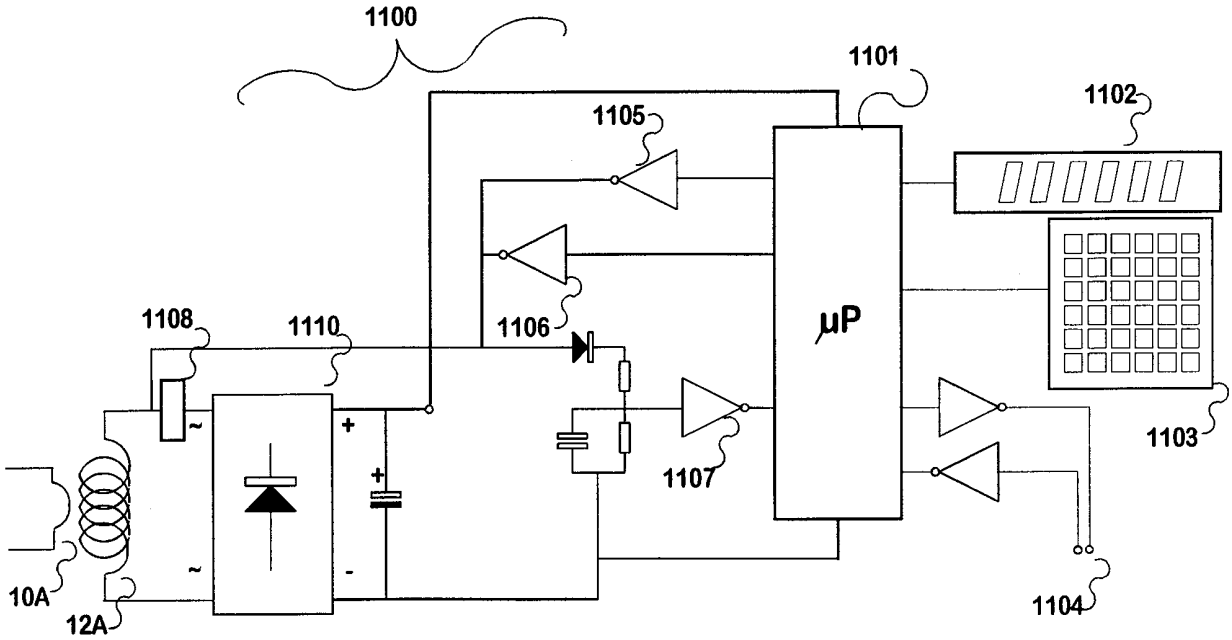


Fig 11

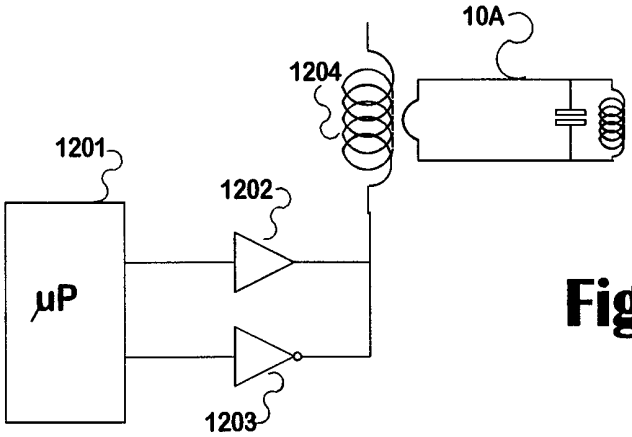


Fig 12

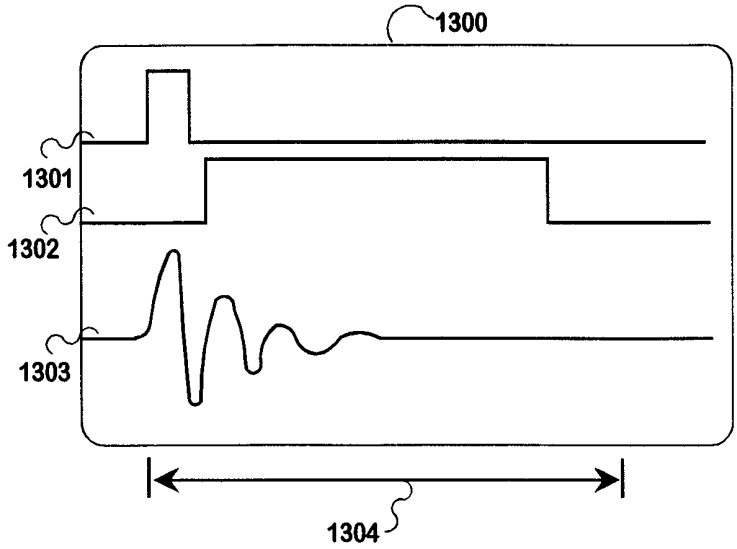


Fig 13

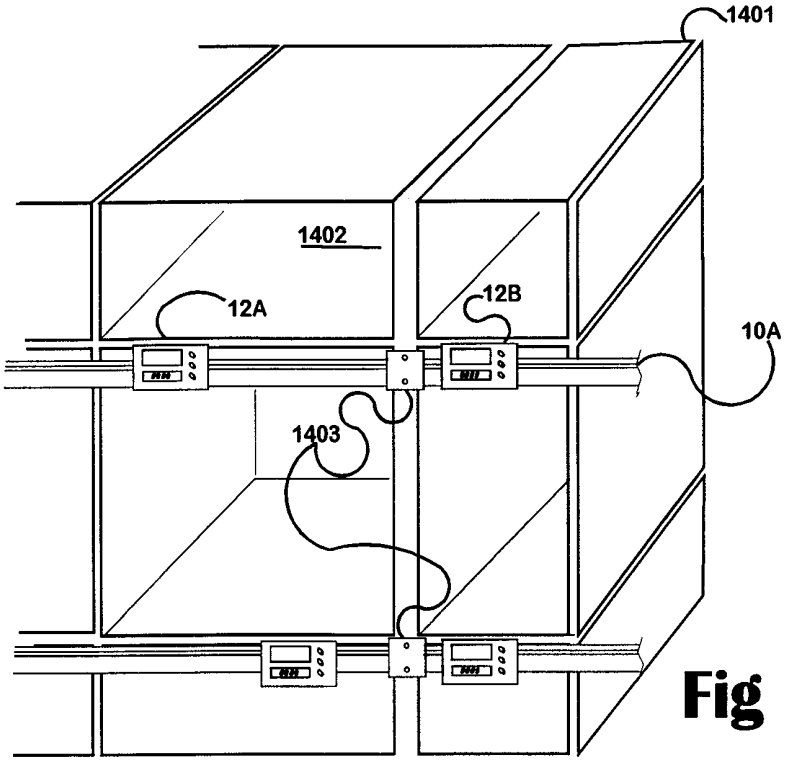


Fig 14

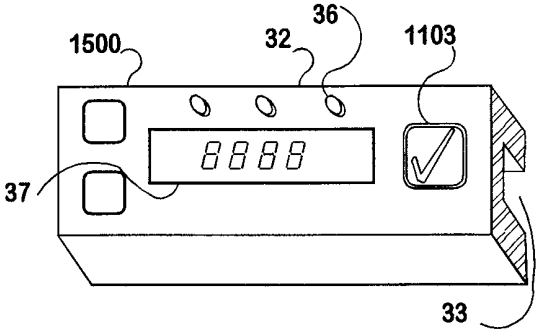


Fig 15

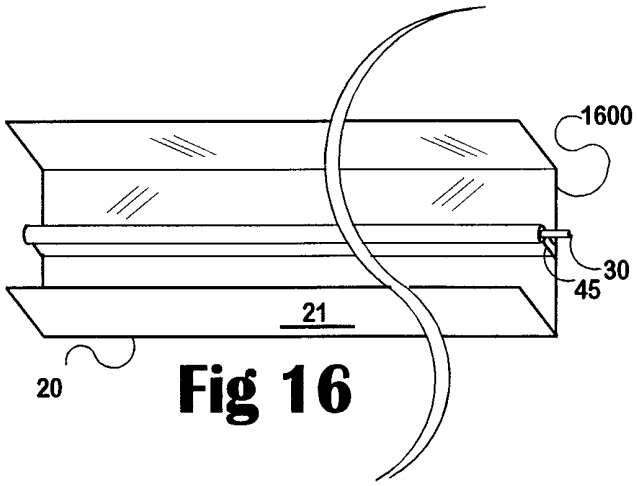


Fig 16

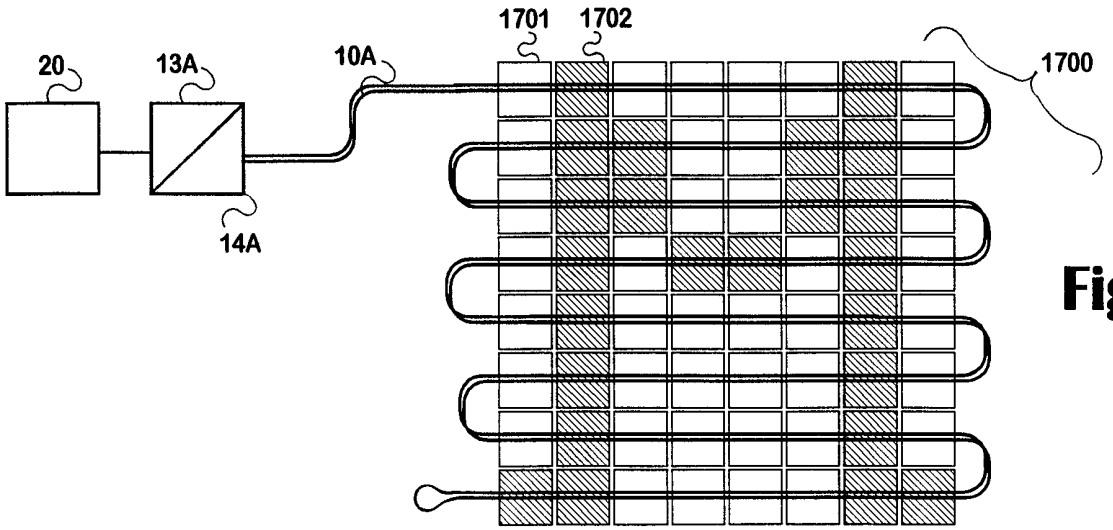


Fig 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ 99/00036

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: G08C17/04, H02J17/00, H04B3/54, B60M5/00

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)
G08C17/04, H02J17/00, H04B3/54, B60M5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC AS ABOVE

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 9857413A, AUCKLAND UNISERVICES LIMITED, 17 December 1998, refer whole document	1-6
Y	US 5293308A, BOYS et al, 8 March 1994, refer whole document	1, 2, 4-6
Y	US 3700886A, BIRKIN, 24 October 1972, refer whole document	1, 2, 4-6

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 June 1999	07 JUL 1999
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (02) 6285 3929	Authorized officer **S KAUL** Telephone No.: (02) 6283

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT	International application No. PCT/NZ 99/00036

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9609595A, SIEMENS AKTIENGESELLSCHAFT, 28 March 1996	
A	WO 9323908A, AUCKLAND UNISERVICES LIMITED, 25 November 1993	
A	US 5207304A, LECHNER et al, 4 May 1993	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NZ 99/00036

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	9857413	AU	79429/98				
US	5293308	AU	12373/92	CA	2106784	EP	577611
		NZ	237572				
US	3700886	CA	939799	CH	524499	DE	2053880
		GB	1293585	ZA	7007257		
WO	9609595	CA	2200467	DE	4433701	EP	782733
		US	5883376				
WO	9323908	AU	40934/93	EP	640254	US	5619078
		US	5898579				

END OF ANNEX