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(54) **Electronic tally apparatus**

(57) An electronic tallying apparatus in which a radio frequency transmitter (10) broadcasts an interrogation signal comprising a sequence of equally spaced r.f. pulses. Transponders (12) receiving the interrogation pulses count (17) said pulses and when the count reaches a value unique to a transponder the transponder emits a response pulse. In the interrogating apparatus a counter (18) is started and counts in synchronism with the interrogation pulses. When each response pulse is received from a transponder a gate (19) is opened, allowing the count reached at that time to be stored in a buffer (20) prior to being decoded (21) into an identity corresponding to that of the transponder. The identities of all transponders responding to an interrogation signal can then be printed out (22).

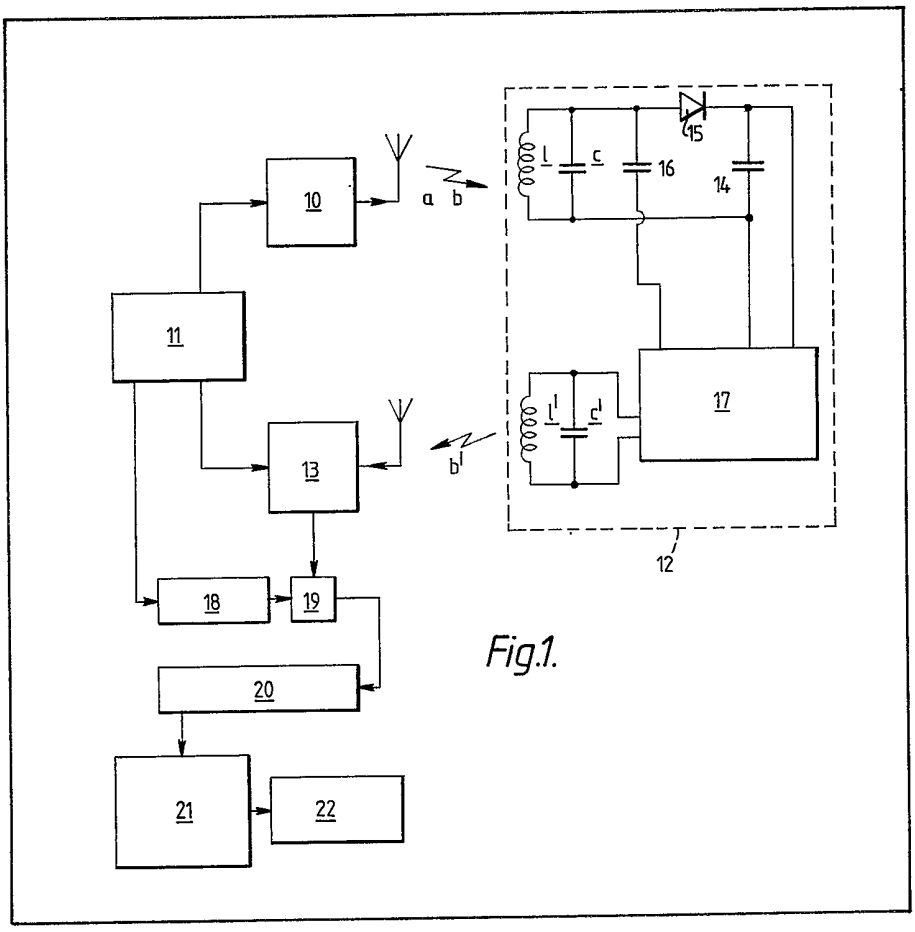

Fig.1.

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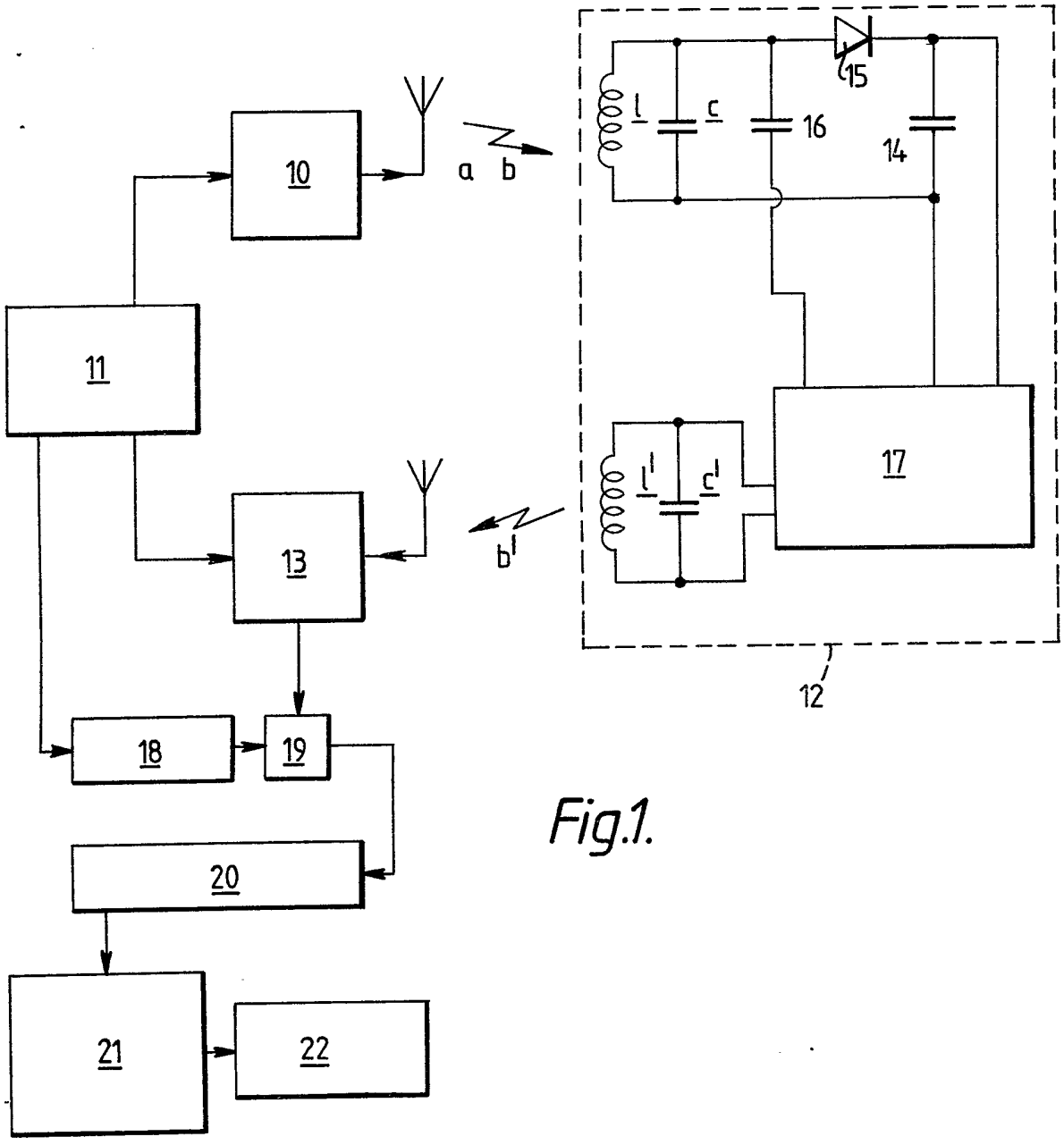


Fig.1.

Fig.2.

Fig.3a.

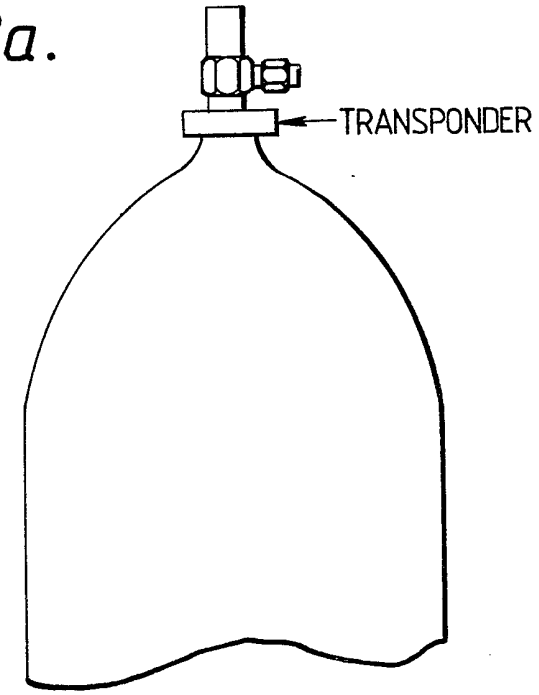
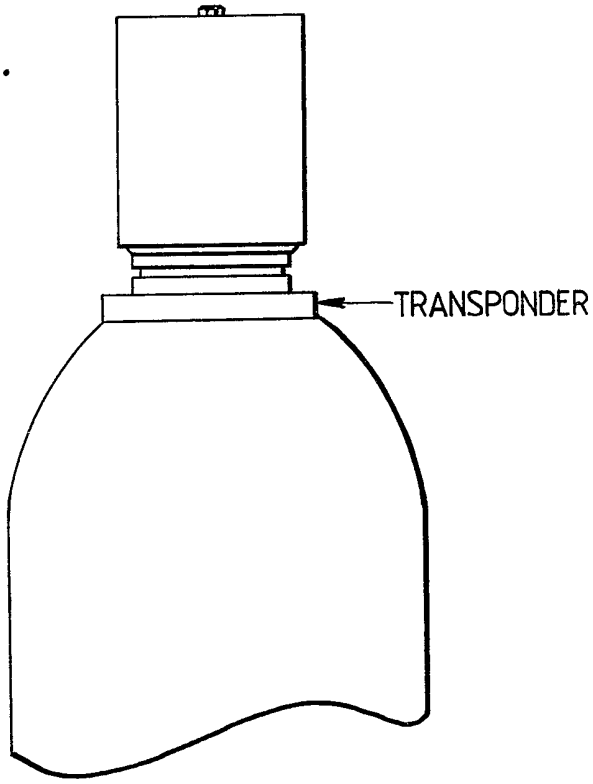


Fig.3b.



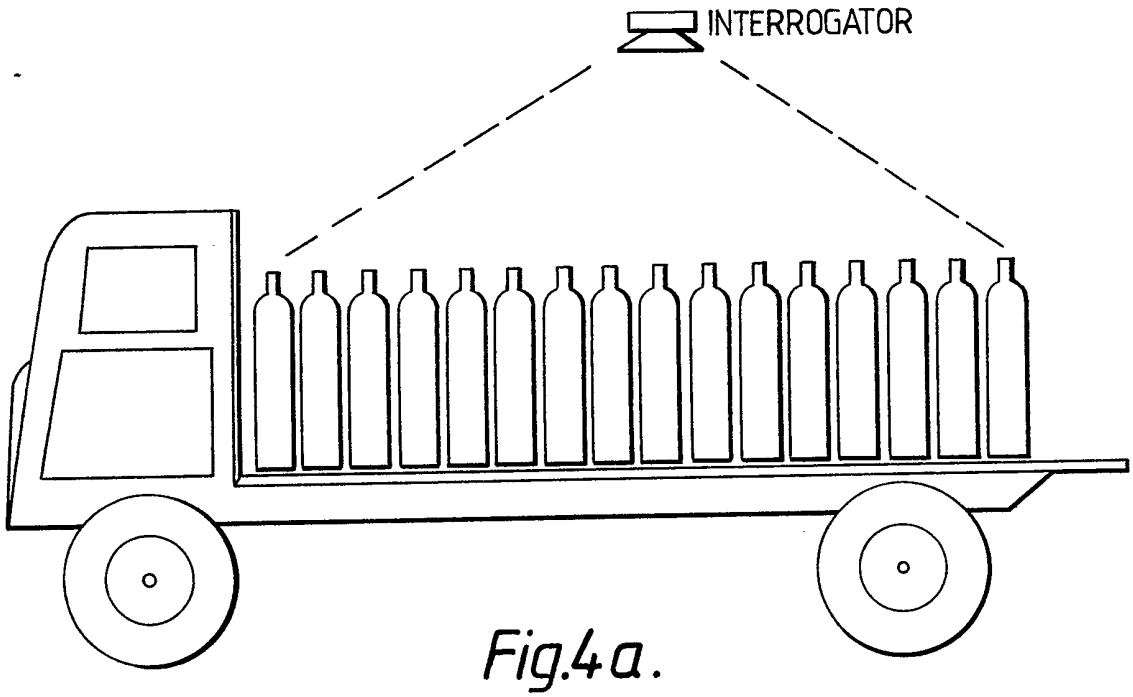


Fig.4a.

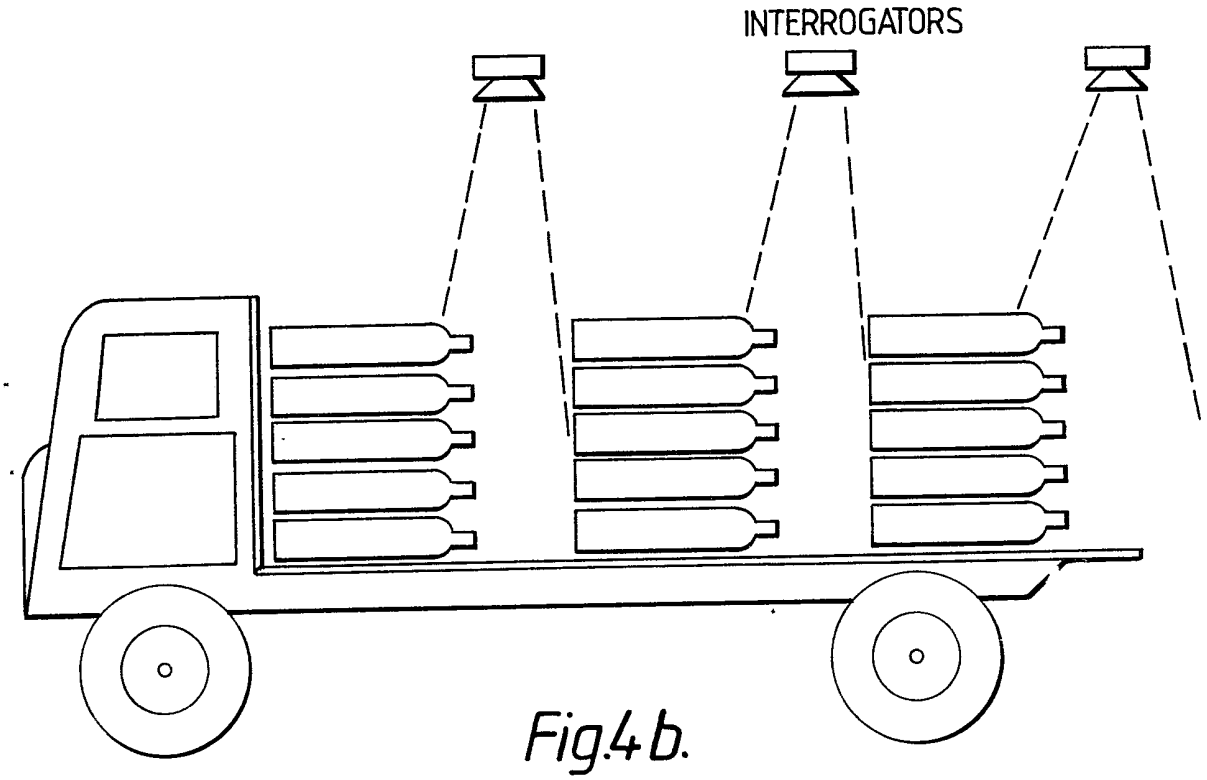


Fig.4b.

SPECIFICATION

Electronic tally apparatus

This invention relates to an electronic tallying apparatus for keeping a tally of goods etc., especially where re-usable items are required to be checked into and out of a warehouse or a factory. A typical application is in tally keeping of gas cylinders. For example the job requirements may be as follows:

Firstly, the number of cylinders available for despatch from the depot, and a detailed description of their contents, should be known at all times. Secondly, each outgoing consignment should be similarly monitored, preferably while on the carrying vehicle and at the moment of departure from the depot. The ability to interrogate the outgoing consignment as it leaves the premises would be a valuable precaution against despatch error or pilferage. By the same mechanism, incoming empties would be monitored on the vehicles as it entered the depot, to be credited to the inventory of cylinders awaiting recharge. With all this information immediately available, the recharging programme could be constantly updated to meet the pattern of outstanding orders.

It is assumed that current practice does not require the specific identification of individual cylinders except by the nature of their contents, on the basis that one cylinder of oxygen is as good as another. Hence, even though each cylinder might bear a unique reference number, it would appear to be expedient to handle them merely on the basis of the contents colour code. However, once a cylinder has been address-labelled in response to a specific order it acquires a specific identity which modifies its subsequent handling. There can be little doubt that losses and inventory errors are most likely to occur while cylinders are passing through their phase of non-specific identity. It is well established in military and other circles that a positive roll-call system is more accurate and conclusive than a simple headcount, it follows that the most secure inventory control would be achieved by identifying each individual cylinder by its unique reference number throughout its handling history, using the same detailed accounting procedure at all stages. Thus, against any given reference number would be recorded cylinder capacity, empty or full, nature of contents, whether held in depot, from whom returned or to whom despatched, the status record being constantly updated.

Implemented by human operatives, such a procedure could become prohibitively complicated and time-consuming, not least because of the very large reference numbers involved in a nation-wide service. However, given an automatic means for interrogation at each handling stage, the relevant data could be processed expeditiously by conventional electronic computer techniques, appropriate printouts being made available to accountants, invoicing staff, loaders, delivery drivers, security guards and others as required. Such a procedure would impose no additional burden on the loading staff, who, in response to a print-out requiring the loading of, say, ten nitrogen cylinders, could still take these at random regardless of reference number, the actual numbers being recorded by the computer at the moment of departure.

Any given gas cylinder, having no distinctive feature to separate it from other cylinders, must necessarily be 'tagged' in some way to give it a unique identity. The broad system of colour coding, made possible by the relatively limited variety of contained gases, must therefore be supplemented by a further code, capable of perhaps a million or more alternatives. For the visual observer, this might take the form of an arrangement of symbols, letters or numbers, but these would be unsuitable for automatic interrogation, for which a binary presentation is to be preferred. Nevertheless, systems involving the use of patterns of optical or magnetic stripes, such as are currently in use for stock control in supermarkets, suffer the limitation that the sensing head must be passed in close proximity to the pattern in order to read it – an undesirable feature in the present context.

In view of the size and weight of the gas cylinders, it would be preferable that their identifying tags should be readable while the cylinders remain in their storage racks or on the transporting vehicle. The undesirable manipulation of the sensing head, whether in position or orientation, would be eliminated by endowing the head with the ability to sense the tags over a distance of several feet, or even several yards. Implicit in this arrangement would be the need to ensure that each tag could be read separately with a large number of other cylinders in close proximity.

According to the present invention there is provided an electronic tallying apparatus including a radio frequency transmitter arranged to broadcast an interrogation signal for reception by a plurality of transponder devices each of which is adapted to transmit a unique response signal, the apparatus also including radio frequency receiving means arranged to receive response signals from transponder devices responding to the interrogation signal, the apparatus further including means for translating said unique signals into corresponding identity signals.

The invention also provides a transponder device including radio frequency receiving means, means for generating a unique response signal in response to a signal received by the receiving means and radio-frequency transmitting means arranged to transmit said unique response signal.

In a preferred embodiment of the invention the tallying apparatus interrogation signal comprises a sequence of equally spaced radio frequency pulses. Each transponder is arranged to count the number of pulses in the interrogation sequence and to emit a radio frequency pulse when a count unique to that transponder is reached. The tallying apparatus

The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

receiver includes a counter which generates a count corresponding to the interrogation pulses and means for putting out the count reached when the or each response signal is received. The counts so put out identify the responding transponders. Each transponder is permanently attached to one article, e.g. a gas cylinder.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:–

Fig. 1 illustrates the basic elements of an electronic tallying apparatus according to the invention,

Fig. 2 illustrates an interrogation pulse sequence,

Fig. 3 illustrates the attachment of transponders to gas cylinders, and

Fig. 4 illustrates alternative methods of interrogating lorry loads of gas cylinders.

The tallying apparatus shown in Fig. 1 consists essentially of a transmitter/receiver equipment working in conjunction with a plurality of transponders. The transmitter 10, under the control of a control unit 11, transmits an interrogation signal which is received by a transponder 12. The reply signal from the transponder 12 is received by receiver 13, also operating under the control of unit 11. The received signals are then processed by the remaining elements of Fig. 1 as will be described later.

Transmitter 10 is caused to broadcast an interrogation signal of the form shown in Fig. 2. The signal commences with a long radio frequency pulse *a* of say 50 milliseconds duration. This is followed by a train of one million short pulses *b* at a frequency of 1 Mb/s. Such a signal can readily be transmitted on a carrier frequency of 1 GHz.

In the transponder 12 the received signals excite a tuned circuit *1c*. The initial long pulse *a* is used to charge a power supply capacitor 14 via rectifying diode 15. At the same time the long pulse *a* acts as a trigger signal to set, via capacitor 16, a counter 17. The counter 17 is preset with a count unique to the transponder and is decremented by the received train of short pulses *b*, also via the capacitor 16. When the counter 17 reaches a count of zero a short reply pulse *b'* is transmitted via a second tuned circuit *1'c'* at a second, different carrier frequency, say 1.1 GHz. The power for the counter 17 and the energising of the second tuned circuit is derived from capacitor 14.

the receiver 13 is disabled by control unit 11 during transmission of the long pulse *a* from transmitter 10. During the transmission of the pulses *b* receiver 13 is operative and will receive any pulses *b'* transmitted from transponders within interrogation range. Meanwhile a counter 18 is started and is incremented by a reference train of short pulses *b''* from control unit 11. The output of counter 18 is applied to a gate 19 which is only opened for one pulse period each time a reply pulse *b'* is received by receiver 13. In this way a binary bit pattern is generated with, say, binary '1's occurring only when a reply pulse is received, the remainder of the pattern being binary '0's. Each binary '1' can be directly translated in terms of a count number into an identity for a transponder. The binary bit pattern is stored in a buffer 20, from whence it can be transferred at a low rate to a decoder 21 which relates each bit to a transponder identity and feeds this identity to a printer 22.

Thus the whole interrogation sequence can be completed in little more than 1 second, although the print-out may take an appreciably longer period. To negate the effect of possible spurious responses it is practicable to repeat the interrogation a number of times, say 6 times in 10 seconds, with 6 buffers 20 being used in turn. When all 6 interrogations have been completed logic (not shown) can compare the successive interrogation results and determine whether there are any inconsistencies and provide an indication and/or alarm accordingly.

All the transponders are identical in every respect except their initial count setting. This would be decided at the time of their original attachment to a cylinder, and can be adjusted in the following manner. The standard transponder circuit card is provided with setting circuits for both states of each counter digit. Any desired identifying code can then be set up by disabling the setting circuit for the unwanted state of each digit, one effective method being to punch through the appropriate conductors on the circuit card. Then, at the moment of energisation, the remaining setting circuits would flip the whole counter to the desired identifying number prior to the count-down.

The construction of the transponders is of course to a large extent determined by the nature of the articles to which they are attached. For example, the shape, weight and ruggedness of typical gas cylinders give rise to handling techniques that could expose an externally-attached transponder to grave risk of damage. Nevertheless, external mounting becomes mandatory, since, not only would it be unacceptable to interfere with the normal construction and function of the cylinder, but the transponder antenna must be exposed with adequate electrical isolation from the cylinder body. A suitable form of construction and mounting might be as shown in Fig. 3*a*. The transponder would take the form of an annulus having a centre hole of a clearing size appropriate to the cylinder valve thread. The desired identifying code number having been set up during its initial assembly, the transponder would merely be placed over the cylinder neck and the valve screwed into place, serving also to lock the transponder in position. Thereafter, the transponder would so remain throughout the life of the cylinder, requiring no further access or adjustment. A different design would be required for those cylinders provided with a neck thread and a cast-iron protective cap, but here the transponder might be screwed on to the neck thread prior to fitting the cap as shown in Fig. 3*b*. It would, of course, be implicit that the fitting of the protective cap should not screen the transponder antenna.

In either case the transponder would lie closely to the upper neck of the cylinder in the vicinity of the valve – a region where caution is normally exercised during cylinder manipulation. Nor would it be possible to suffer damage should the cylinder simply roll or fall over. A rugged form of construction would nevertheless be adopted, capable of resisting the

reasonable impact of spanners and the like. The overall size would be dictated primarily by the antenna design and by the bulk of the protective housing, since the electronics proper would occupy a relatively modest space.

It is imperative that the transponder anetanna shall have radio-frequency access to the interrogator head, and shall not be subject to screening or shadowing by storage racks or other cylinders. However, since it is envisaged that cylinders are normally stored and transported with their valve heads collectively presented either upwards or sideways, no insuperable problems are anticipated. Fig. 4*a* shows a suitably mounted interrogator for a vehicle loaded with vertical cylinders. Horizontal loads, such as in Fig. 4*b*, might require supplementary interrogation heads to fill in any dead spots. A similar philosophy would be applied to the location of interrogation heads within a warehouse. The true requirements would be confirmed by the opportunity to perform propagation tests in an actual storage depot.

The monitoring facility offered by this invention might be confined merely to the checking of departing loads. Nevertheless, the detailed information so obtained, if correlated with the results of monitoring other stages in the processing cycle, could be made the basis of a comprehensive, direct-input, computer accounting procedure, with all the currently-recognised advantages of faster processing, additional data and freedom from human error.

The standardisation of size and shape of gas cylinders makes them excellent subjects for a completely automatic handling and loading system. An essential feature of such a system is that the travelling grab must be capable of recognising which cylinder it is to pick up. The present invention offers this facility, making it possible for the grab to operate in a 'search' mode until it received a response from the cylinder for which it was seeking. To this end, a short-range, one at a time interrogation method would be used. Alternatively, a returned cylinder, selected at random for an incoming vehicle, could be immediately identified and transferred to its correct recharging location.

Since the complete cycle need occupy no more than one second, it is practical to apply the method during the movement of individual cylinders. In this case, an interrogating antenna of deliberately limited range can be mounted on the crane or grab.

Whilst the invention has been primarily described in terms of identifying gas cylinders it is envisaged that it has practical applications in many other fields, notably those in which a large number of items are used in a short term hire or rental mode. Cans, casks, clothing etc. are some possible applications. The invention also lends itself to security applications. Personnel each equipped with a transponder can be interrogated automatically at the entrances to and exits from work areas, their identities recorded at appropriate times and access to secure areas being automatically controlled with the minimum of delay.

CLAIMS

1. An electronic tallying apparatus including a radio frequency transmitter arranged to broadcast an interrogation signal for reception by a plurality of transponder devices each of which is adapted to transmit a unique response signal, the apparatus also including radio frequency receiving means arranged to receive response signals from transponder devices responding to the interrogation signal, the apparatus further including means for translating said unique signals into corresponding identity signals.

2. Apparatus according to claim 1 wherein said transmitter and said receiving means are arranged to operate on different frequencies.

3. Apparatus according to claim 1 or 2 wherein the interrogation signal comprises a sequence of equally spaced radio frequency pulses.

4. Apparatus according to claim 3 including a counter which generates a count corresponding to the interrogation pulses and means for putting out the count received when the or each transponder response signal is received.

5. Apparatus according to claim 3 or 4 wherein the transmitter is arranged to precede each interrogation signal with a continuous radio frequency signal of predetermined duration longer than that of an interrogation pulse.

6. Apparatus according to claim 5 including means for disabling the receiving means during transmission of the continuous radio frequency signal preceding an interrogation signal.

7. Apparatus according to claim 4 including buffer means in which each count put out from the counter is temporarily stored and decoding means to which the stored counts are applied, the decoding means being arranged to translate each count so stored into a transponder identity.

8. Apparatus according to claim 7 including means for printing out the transponder identities as translated by the decoding means.

9. Apparatus according to any preceding claim including a plurality of storage means wherein the translated signals from a number of repeated interrogation signals are individually stored and logic means for comparing successive interrogation results to determine whether there are any inconsistencies in said stored translated signals.

10. Apparatus according to claim 9 including means for indicating when inconsistencies occur in the translated signals derived from corresponding responses to succeeding interrogation signals.

11. An electronic tallying apparatus substantially as described with reference to the accompanying drawings.

12. A transponder device for use with the apparatus as claimed in any preceding claim, the transponder device including radio frequency receiving means, means for generating a unique response signal in response to an interrogation signal received by the receiving means and radio frequency transmitting means arranged to transmit said unique response signal.

13. A device according to claim 12 including a counter arranged to count pulses in an interrogation signal, the transmitting means being arranged to emit a radio frequency pulse when a count unique to the device is reached.

14. A device according to claim 12 or 13 including a capacitor, means for charging the capacitor in response to a received continuous radio frequency signal of predetermined duration preceding an interrogation signal, said capacitor providing power for the device during receipt of the ensuing interrogation signal.

15. A device according to claim 12, 13 or 14 wherein the receiving means and the transmitting means are arranged to operate at different radio frequencies.

16. A device according to any one of claims 12 to 15 constructed in the form of an annulus.

17. A transponder device substantially as described with reference to the accompanying drawings.

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