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(54) Weighing apparatus

(57) Weighing apparatus comprises a dynamometer 11, e.g. of the vibrating string type, and electronic evaluating device 12, including data processing means operating in accordance with the disclosure of U.K. Patent Specification No. 1494302 to provide a read-out of the weight and/or price of an object 18. The data processing means receives electrical pulses from the dynamometer 11 via the cable 13 and additionally receives the values of the constants which are specific to the particular dynamometer from a data store housed in the plug 14 at the end of cable 13 or located inside the dynamometer housing 16. The data store comprises a programmed read only memory and is pre-loaded with the values of the constants which are specific to the particular dynamometer 11. This makes the dynamometer independent of the evaluating device 12 so that any one of a number of dynamometers 11 can be connected interchangeably with an evaluating device.

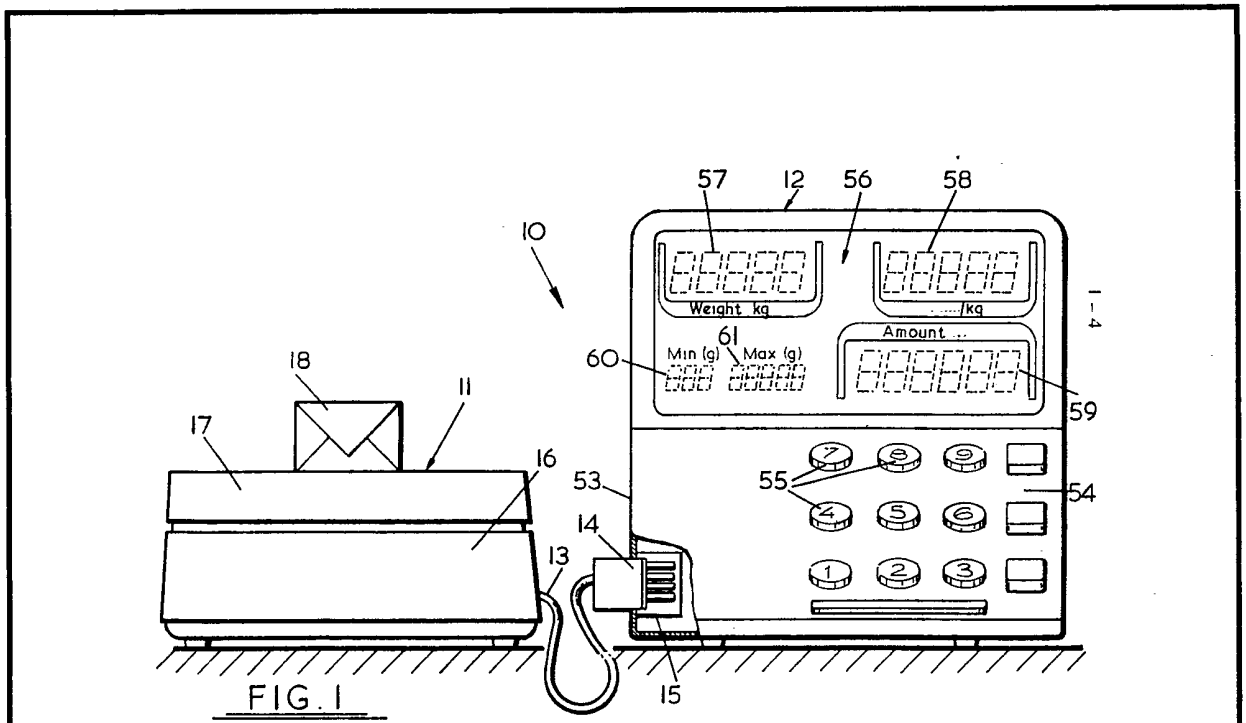

FIG. 1

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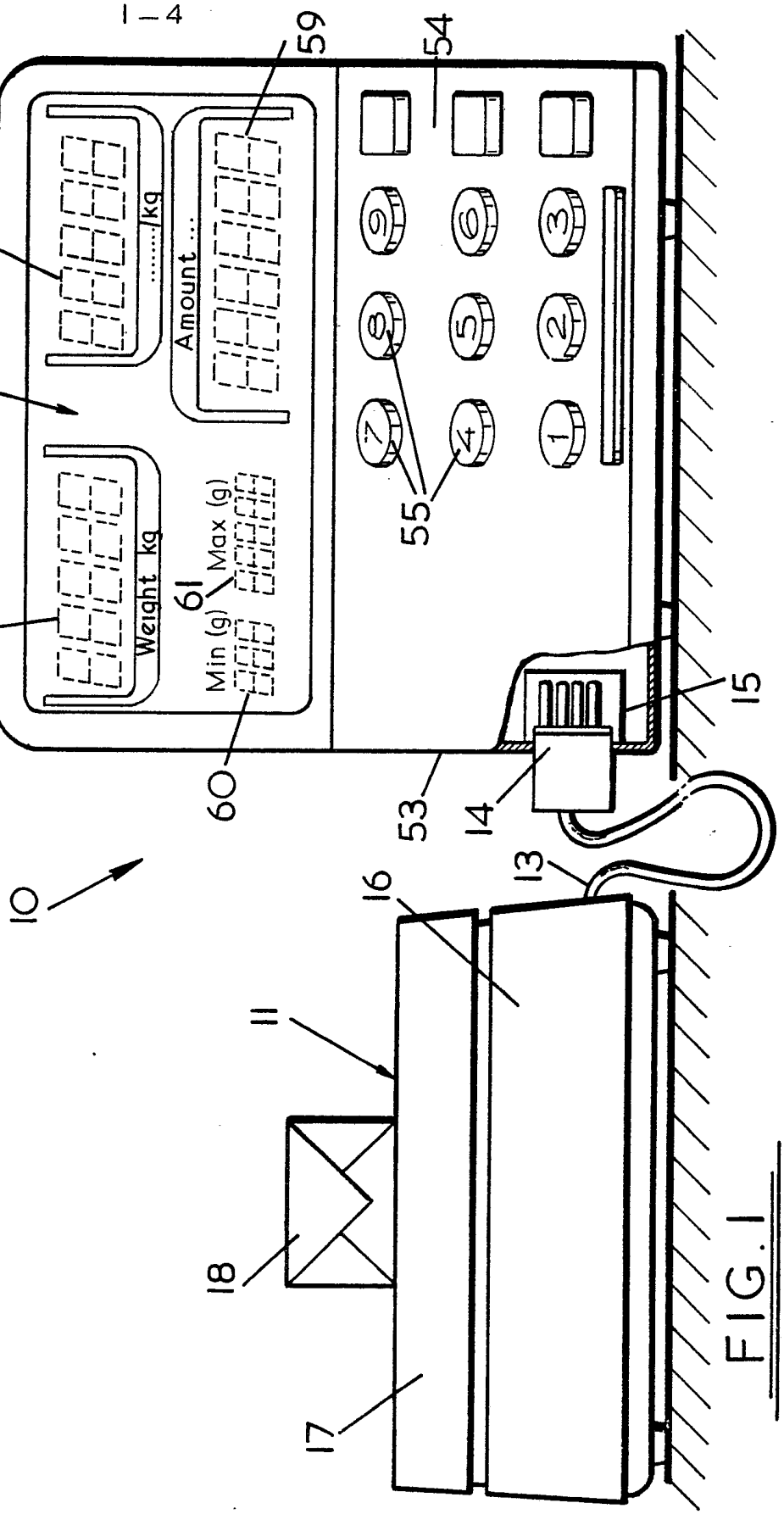
59
54
58
56
12
57
55
61
60
53
14
15
13
16
11
18
17
10
Amount...
Weight kg
Max (g)
Min (g)
/kg

FIG. 1

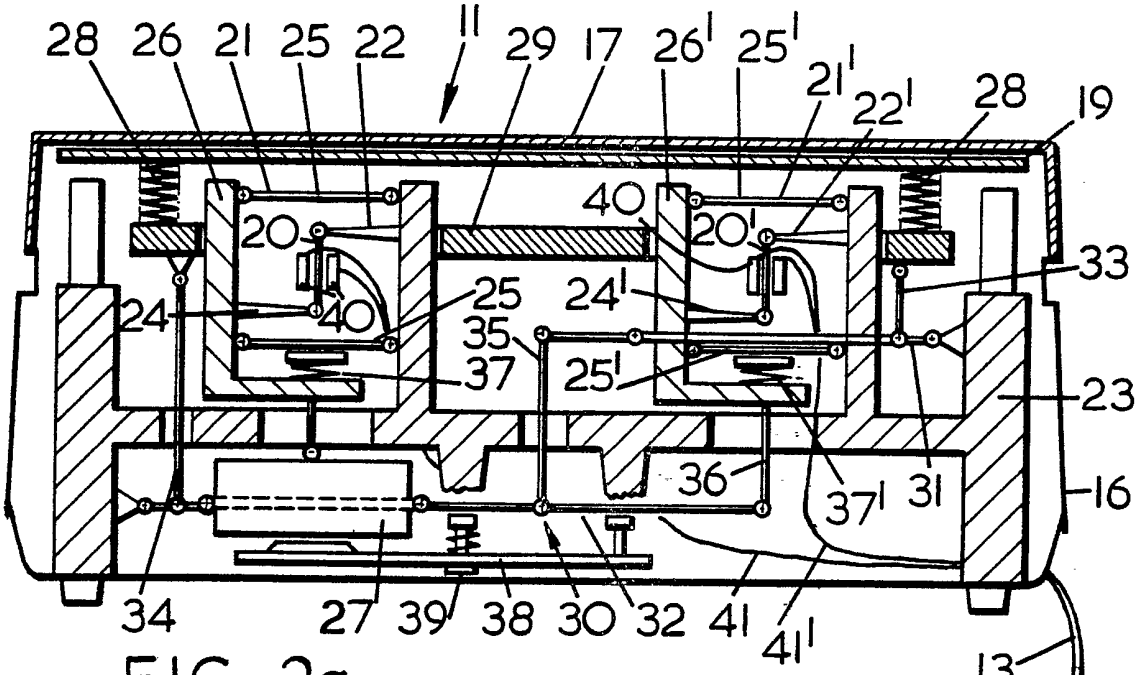

FIG. 2a

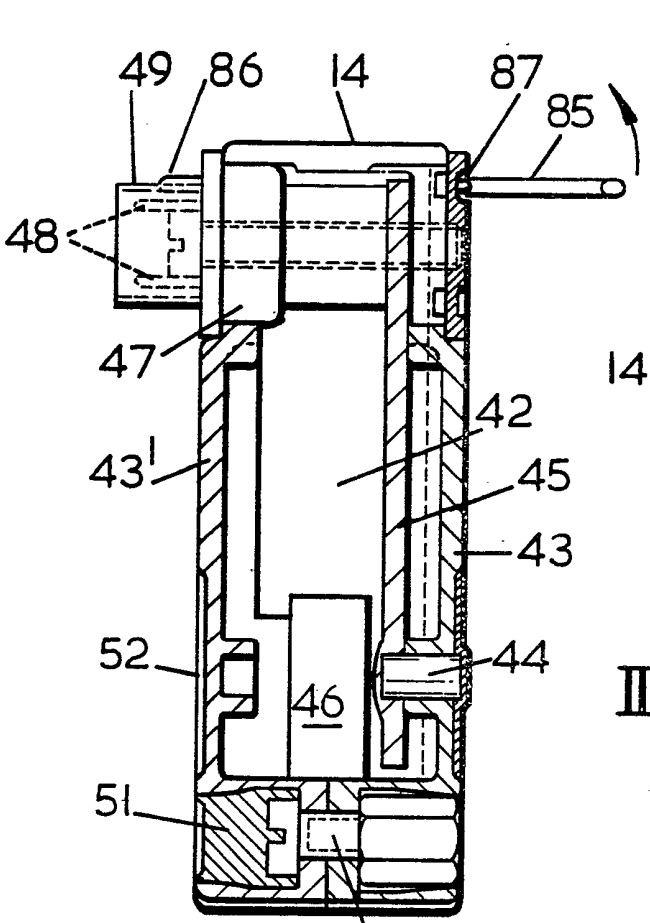

FIG. 3

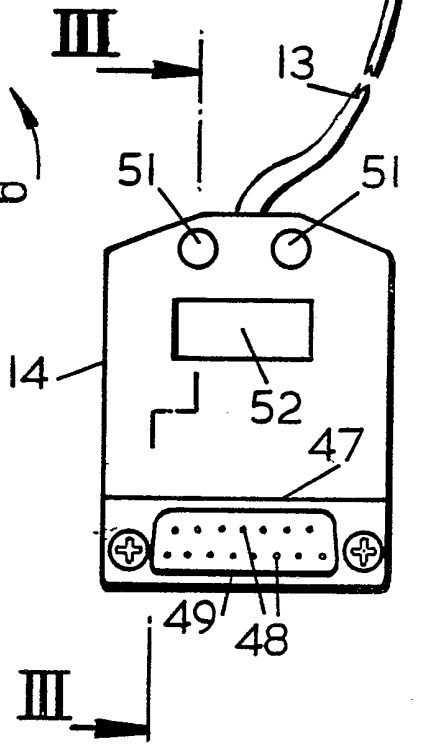

FIG. 2b

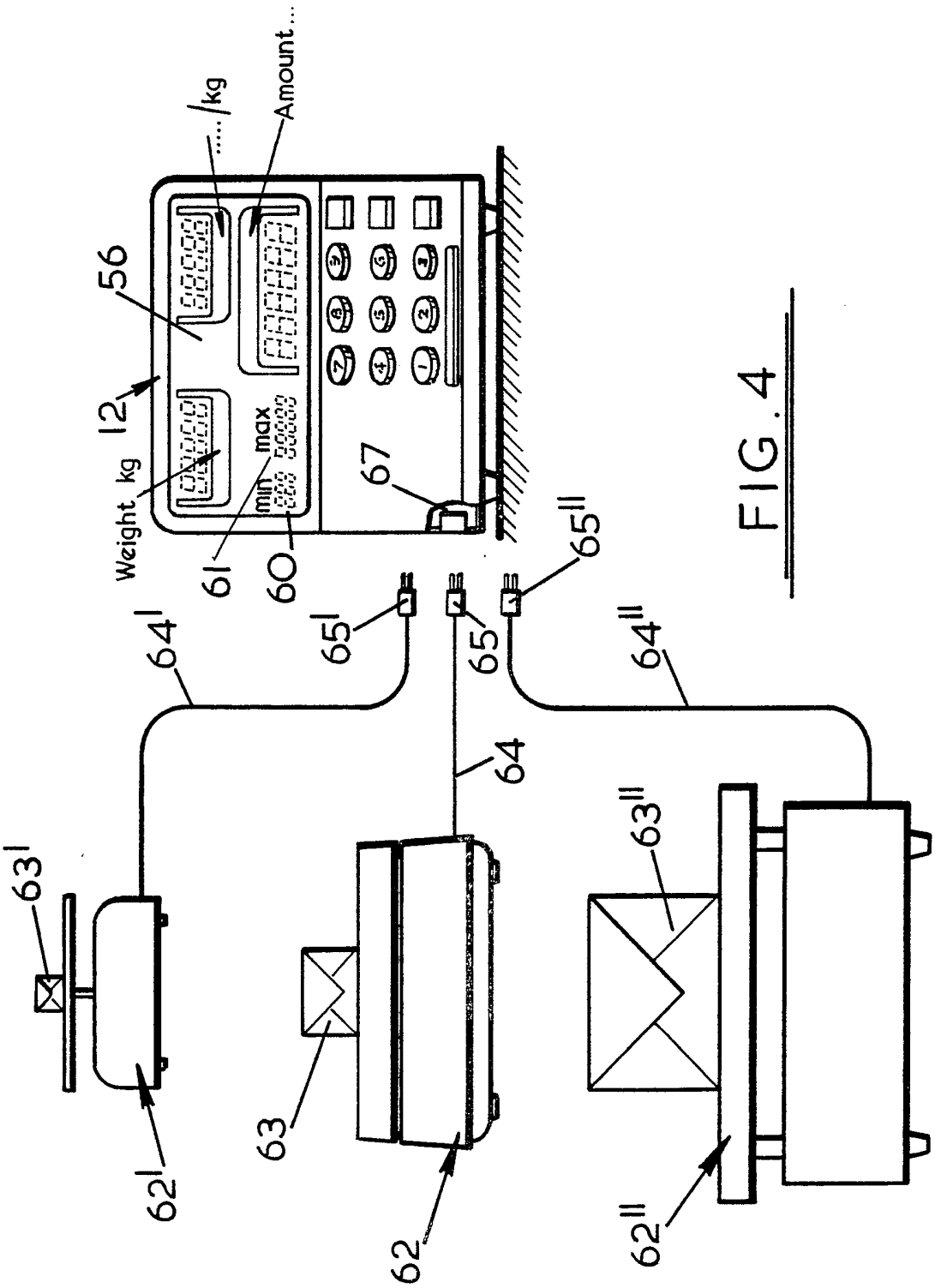
Amount....
/kg
56
12
Weight kg
min max
61
60
67
65II
65I
65
64I
64II
64
63I
63II
63
62I
62
62II

FIG. 4

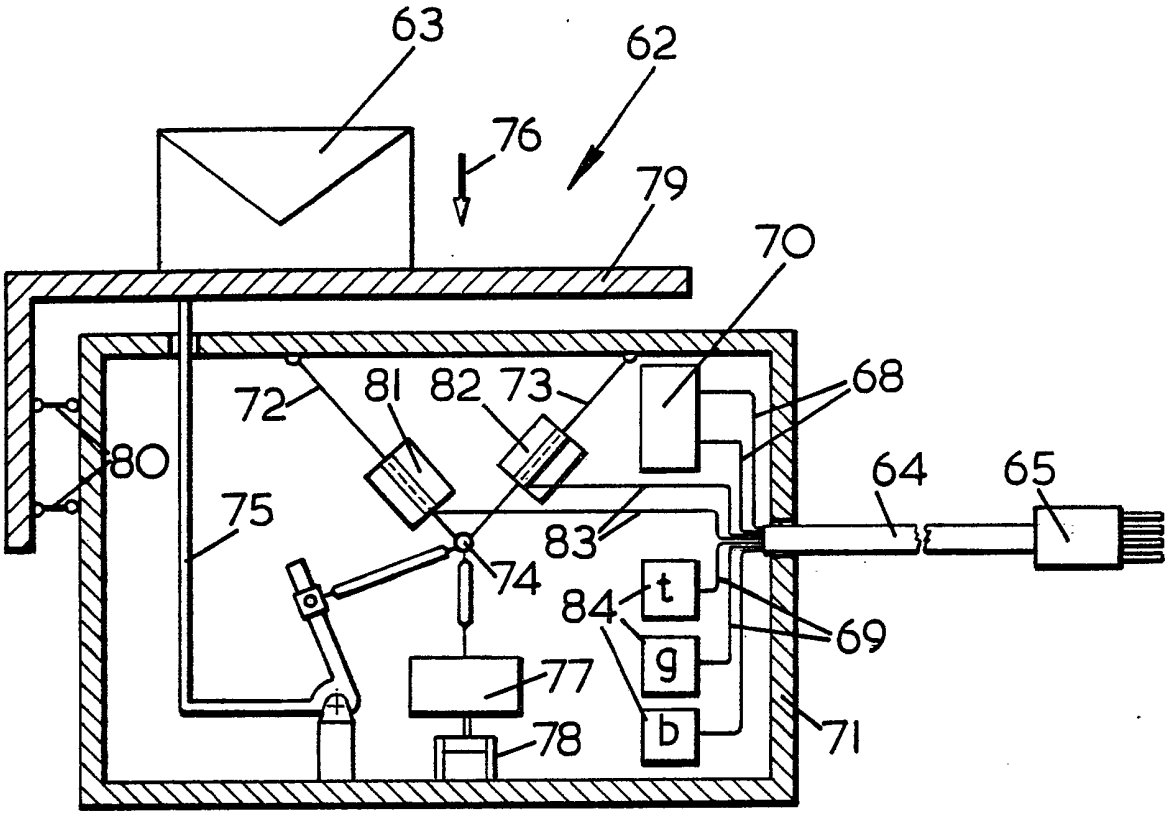

FIG. 5

SPECIFICATION

Weighing apparatus

The invention relates to a weighing apparatus of the type comprising a dynamometer and an electronic evaluating device. The dynamometer is actuated by the object being weighed and emits electrical pulses. A weight sensor in the form of a gauge chamber with oscillating strings is particularly suitable as a dynamometer. The electronic evaluating device is linked to this dynamometer via an electrical connection and receives its measurement pulses. The evaluating device includes a calculator and a display for the weight and/or price values ascertained or calculated.

With the known weighing apparatus of this type, a data store is included in the electronic evaluating device next to the calculator. The function of this data store is to hold the ascertained values of weight or price and to output them, for instance, through the display in the form of a printer. This is useful, for example, for the provision of interim totals when a list is wanted of the values measured or calculated on the weighing apparatus over a certain period of time. Data stores also play a part in calculators for storing intermediate figures or for calculating the final measured value from a number or for calculating the final measured value from a number of individual measurements by ascertaining the mean value or the like.

In our U.K. Patent No. 1,494,302 we have proposed on improved form of weighing apparatus in which there is no need to perform complicated mechanical adjustments of the dynamometer weight sensor but, instead, the output signal from the unadjusted dynamometer is fed to a data processor forming part of the evaluating device and the weight (G) of the commodity evaluated on the basis of a polynomial:

$$G = a_0 + a_1 s + a_2 s^2 + \ldots a_n s^n$$

where a_0, $a_1 \ldots a_n$ are constants characterising the dynamometer, and s is the electrical output signal from the dynamometer. To implement this proposal the constants a_0, a_1 etc. were first evaluated by using standard test weights and the numerical values of the constants were contained in a data store forming part of the evaluating device.

The object of the present invention is to provide a weighing apparatus of the type indicated above, which makes it possible interchangeably to use different dynamometers with an electronic evaluating device.

This is achieved in accordance with the invention in that the dynamometer is fitted with a tamper-proof data store which holds the constants characteristic of this dynamometer and which—as a fixed component of the dynamometer part of the apparatus—is linked to the electrical connection leading to the evaluating device, a connection which is normally used for transmitting the measurement pulses but which can now also be used to call up the constants for use by the evaluating device. The data store, which is permanently attached to the dynamometer, holds all the specific constants which characterise this particular dynamometer compared with any others. This means that every dynamometer is the same for calculation purposes as far as the electronic evaluating device connected to it is concerned, once the constants stored in the dynamometer have been taken into account. In this way it is possible, very simply, quickly and accurately, to make individual corrections to the constants of each dynamometer such as are required to compensate for the particular ambient conditions where the dynamometer is used, e.g. temperature, gravitational acceleration, and support structure vibrations simply by inputting the individual correction figures into the integrated data store, the corrected constants then being automatically taken into account by the electronic evaluating device connected, together with the measurement pulses being received. In this way the weight-sensor of the dynamometer does not need to be set or adjusted at all. Instead, only the characteristic constants have to be entered into its data store. With the PROM (programmable read-only memory) technology available today, this can be done very quickly and easily in terms of space, cost and labour. Every dynamometer is thus accurately matched with regard to its measurement pulses by its own data store, despite its individual variations due to manufacture and assembly.

Although it is possible to locate the data store inside the dynamometer housing, it is better simply to use the dynamometer housing, it is better simply to use the dynamometer side of the coupling member for the electrical connection between the dynamometer and evaluating device for this purpose, i.e. on the end of the cable leading from the dynamometer housing which is plugged into a corresponding countercoupling member on the housing of the evaluating device. The small size of the data store enables it to be incorporated in such a coupling member without any difficulty. The increase in the size of such a coupling member, e.g. a plug, is relatively insignificant, and in fact it makes it easier to plug the coupling member in and to pull it out. The valuable space within the housing of the dynamometer or of the evaluating device can then be kept free for other components. It is particularly worth noting that with this arrangement there do not have to be extra leads in the connecting cable, but that a slim, flexible cable is sufficient; the multi-core leads for the constants to be called

up only extend from the evaluating device to the coupling member at the end of the cable.

The present invention also provides weighing apparatus as claimed in claim 1 of U.K. Patent Specification No. 1494302 wherein said constants are held in a data store which together with said transducer forms part of a dynamometer module, the values of the constants being specific to the particular transducer of the module, said data processing means and read-out means form part of an evaluating device module and said modules are disengageably electrically interconnected.

The invention can be realised in a great many different ways, with basically two methods of application which may, of course, also be used together.

The first method dispenses with any components and processes required for performing settings and adjustments within the dynamometer. In the case of weight sensors in the form of gauge chambers fitted with oscillating strings, there is no longer any need to tie several measuring strings together at certain angles and to actuate them at the correct angle with the measurement force on the one hand and a reference force on the other, to compensate for errors in linearity, zero load or the like. Instead, a single measuring string can be actuated by the weight of the object being weighed and other comparison string by the constant reference weight, all corrections for stationary errors being recorded in the constants for calculation purposes. These constants are entered individually into the data stores of the appropriate dynamometer. The corrections themselves are performed arithmetically on the measurement pulses as they are received in the electronic evaluating device connected. U.K. Patent No. 1494302 shows a possible configuration for such a calculator. The precise individual data for this, i.e. the coefficients indicated there, are supplied by the dynamometer from its built-in data store, the contents of which are tailored precisely for the dynamometer in question. Not only can all stationary errors be corrected thereby but also all dynamic variations which may occur at any particular moment of measurement. Thus a constant value recorded in the data store built into the dynamometer may be the individual temperature coefficients of this component, which are then included in the computation in the evaluating device. Similarly, reference values for changes in acceleration due to gravity or correction values for vibrations of the support structure occurring during weighing can be entered into the data store and will be taken into account by the evaluating device when it evaluates the measurement pulses. All individual variations are held in the dynamometer's data store. This type of data can be rendered taper-proof by sealing or the like, e.g. by being enclosed in the coupling element of the connecting cable mentioned above.

The standardization, for evaluation purposes, of a variety of individual dynamometers of one type enables each of the dynamometers in question to be connected to an existing evaluating device with equal success. It is not necessary for the dynamometer and the evaluating device to be specifically coordinate. If sold or exchanged for repair, any of the dynamometers can perform equally well with a particular evaluating device.

In addition, however, the invention can also be applied to different types of dynamometer weight-sensors, which can now be connected to a standard evaluating device with universal display. Typical reference values can be entered into the data store incorporated into each of the dynamometers in question and are then taken into account by the evaluating device, together with the measurement pulses being received, for calculation and display purposes. In this way a single universal evaluating device can be used for the most varied types of dynamometer weight-sensors. Not only can dynamometers of varying capacity, sensitivity and measurement graduations be reliably interpreted by the same evaluating device, with accurate reproduction of weights and/or prices in its display, but dynamometers constructed in accordance with very different design principles can be universally connected to one evaluating device of a standard type. Thus, dynamometers of mechanical design, the measured values of which are converted into electrical measurement pulses, can be connected up to a common evaluating device alongside strain gauge dynamometers. All the typical adjustments to measured values coming from any one type can be entered in the form of fixed references values, i.e. constants, into the data stores incorporated in each of the dynamometers in question and are included in the computation in the evaluating device, which reproduces the weights correctly in its display. The said reference values can also be displayed, in addition, in a separate display in the evaluating device so that they can be read and checked by the person using the weighing machine.

Stored data designating quality and quantity relating to the dynamometer can also be displayed, depending on its type. This includes an indication of the maximum measuring range of the weighing machine connected to the evaluating device, i.e. in the case of a weighing machine in a shop, the maximum weight to be measured in grams; also an indication of the accuracy of the weighing machine i.e. whether the commodity on the machine is weighed in graduations of one or two grams. The type of weight-sensor can also be shown by a digit in the display window of the evaluating device, in the form of a number or symbol for the person using the machine to read off. Finally, the tare weight of

the packaging which is subsequently going to be filled with the commodity by weight can be shown initially in the display window.

Such readings on the measuring accuracy and grade of the weighing machine can be employed in principle for all applications. Furthermore, control readings on the quality of the dynamometer can also be shown in the display window as required, enabling defects and changes to be monitored. Instead of, or in addition to, the visual display, e.g. on a liquid crystal basis, the reading can also be passed through a printer belonging or connected to the evaluating device, which records all the said data on a check slip or on a label to be subsequently affixed to the commodity.

The drawings illustrate, by way of example, several embodiments of the invention. They show:

Figure 1 a first embodiment of the weighing device according to the invention, wherein the data store is incorporated in the plug element of the dynamometer;

Figure 2a the longitudinal section through the housing surrounding the dynamometer, with the most important components shown schematically;

Figure 2b an end view of the plug member attached to its cable, approximately life size;

Figure 3 in enlarged longitudinal section along section III–III, an inverted view through the plug member of Fig. 2b;

Figure 4 a schematic side view of another embodiment of the weighing device with several dynamometers of different types, which can be used selectively, connected up to a standard evaluating device; and

Figure 5 as schematic sectional view through one dynamometer housing shown in Fig. 4.

The weighing apparatus 10 in the embodiment shown in Figs. 1 to 3 comprises two components which can be positioned independently of each other. One component is a dynamometer 11 and the other component an electronic evaluating device 12. These components 11, 12 are connected with each other by means of a cable 13, one end of which is permanently attached to the dynamometer 11, the other end carrying a plug member 14 which, as can be seen from the cut-away view in Fig. 1, is coupled into a corresponding socket 15 in the evaluating device 12.

As illustrated in Figs. 1 and 2a, the dynamometer 11 comprises a base housing 16, the top of which is covered by a load pan 17. The load pan 17 is for holding the commodity to be weighed, e.g. the package of merchandise 18 shown in Fig. 1. The measurement of weight is effected by measuring cells or weight-sensors 21, 21′ with oscillating strings which in the present case are arranged simply as single strings 20, 20′ in the two measuring cells 21, 21′. Other conventional measuring cells of this oscillating-string type or movements of other types could of course also be used. The construction illustrated, however, is particularly simple in that one end of each of the strings 20, 20′ is attached by a mounting 22, 22′ illustrated schematically, to a frame 23 fixed in the housing 16, while the other ends of the two strings are attached by mountings 24, 24′ to supports 26, 26′ hinged to the frame 23 via parallelogram guide rods 25, 25′. The string 20 in the measuring cell 21 is acted upon solely by a reference weight 27, which engages the support 26 through an overload safety device 37. The string 20′ in the other measuring cell 21′ is acted upon solely by the weight of the object to be weighed 18, which acts on a load bridge 29 from the load pan 17 via a lower plate 19 and interposed spring-loaded elements. The load bridge 29 is supported on the frame 23 by a lever system 30 which comprises two levers 31, 32, one end of each of which is fixed by a swivel attachment to the frame 23 and which are connected to the load bridge 29 by coupling rods 33, 34 respectively and with each other by a coupling rod 35. A further coupling rod 36 links this system of levers 30 via an overload safety device 37′ to the support 26′ in the measuring cell 21′. The two levers 31, 32 are fitted with an annular portion enveloping the area of this measuring cell 21′ on the one hand and the area of the reference weight 27 on the other. To lock the reference weight 27 and the lower lever 32, and so the entire system of levers 30, a locking lever 38 is used, which is operated by means of a spring-loaded screw connection 39.

For the excitation of the two strings 20, 20′, electromagnets 40, 40′ are used which at the same time act as oscillation sensors for determining the natural oscillations of the loaded strings, and which transmit the corresponding measurement pulses through the electric wires 41, 41′ indicated to the leads in the cable 13 permanently attached to the housing 16 of the dynamometer and terminating at the plug member 14. In practise, five leads in the cable 13 are sufficient for this purpose.

As illustrated in Figs. 2b and 3, the housing of the plug member 14 is in two parts 43, 43′. The lower part 43 of the housing has fixed to it, by means of a rivet fastening 44 or the like, a printed circuit board 45 on which one or more components of a data store 42 are mounted and which contains a pre-programmed electronic memory (PROM). The electrical connections from the data store 42, for example ten in number, are connected to a module 47 with connector pins 48 as are the five leads in the cable 13 referred to above. The leads in the cable 13 enter the plug member 14 and terminate at a connector block 46 which is pre-wired to the module 47. The module 47 comprises fifteen pins 48

arranged in two rows inside a protective sleeve 49. The upper part of the housing 43' consists of a cover plate connected to the lower part of the housing 43 by screw connections 50, with the screws made inaccessible by a seal 51, thus rendering the data store 42 inaccessible and taper-proof. The upper part of the housing 43' may also incorporate a recess 52 for showing details of the type, quality and grade of the dynamometer 11.

The data store 42 holds all specific data relating to the two measuring cells 21, 21', and thereby saving any laborious adjustments. The data store holds constants which are arranged according to the particular characteristics of the cells 21, 21' concerned and can be evaluated and displayed by the calculating elements of the evaluating device 12 connected to it, together with the measurement pulses received from the two cells 21, 21'. The evaluating device 12 is constructed as follows: in the present case, where the application illustrated is for a weighing machine for use in shops, the housing 53 of the evaluating device 12 comprises a sloping panel 54 with a conventional keyboard 55 for inputting the price per kilo of the commodity 18. The housing 53 comprises in its upper part a large display window 56 where, in a number of different fields, various values determined and calculated can be digitially displayed. The individual display digits are formed, for example, by the conventional seven segment method. The display 56 comprises a first display field 57 for showing the determined weight of the commodity 18. For this purpose the measurement pulses and constants received via the plug member 14 are evaluated by the micro-processor calculating elements (not shown) in the evaluating device 12 in the nature of a polynomial of the nth degree as set forth in U.K. Patent No. 1494302. The data store 42 referred to above carries as constants the n coefficients for this calculation in the evaluating device 12. The frequency ratio of the two measuring strings 20, 20' enters this calculation as a measurement signal and the weight value is determined accordingly. In this way the zero position of the specific characteristic of this dynamometer, and then its insufficient linearity, are corrected arithmetically. The value determined then appears in the display field 57. In another display field 58 the price per kilo of the commodity 18 entered through the keyboard 55 is shown, and in the display field 59 the price of the commodity 18 resulting from the weight determination in field 57. The data store 42 in the plug member 14 of the dynamometer 11, however, also comprises, displayed in additional display fields 60 and 61 of the evaluating device 12, characteristic values of the type of dynamometer being used, viz., in display field 61, the maximum weight for which this dynamometer 11 is structurally designed, for example the value "12 kilograms" could be displayed. The other display field 60 shows a minimum weight and/or a value signifying the degree of sesnsitivity of the dynamometer, for example the value "2 grams". The commodity 18 is therefore weighed on the dynamometer 11 to this degree of accuracy.

In the event of failure of the dynamometer 11 or the evaluating device 12, either part can be easily replaced, as exhangeability of the components and precise indication in the evaluating device 12 are always assured, independently of the particular properties of the dynamometer 11, by the fact that the data store 42 is integrated with the dynamometer 11.

Fig. 3 also shows the holding position of a retaining clip 85 fixing the plug member 14 to an evaluating device in the coupled state, the clip pivoting with angled shank ends 86 on the housing 53 (not shown in detail at this point) of the evaluating device 12. In the position illustrated in Fig. 3, the clip 85 engages with its S-shaped spring-loaded rear portion into a retaining slot 87 on the outside of the plug housing 43, thus securing the coupled position. To disengage it, the clip 85 need only be turned back in the direction indicated by the arrow, which enables its pins 48 to be withdrawn from the matching coupling sockets in the evaluating device 12.

In the embodiment of Figs. 4 and 5, an evaluating device 12 is shown to which can be connected, as desired not only to individually different dynamometers but even dynamometers of different types 62, 62', 62", which can contain any desired measuring cells and, as can be seen from the different sizes of commodities 63, 63', 63", have any desired measuring ranges and weight graduations. Any of the different types of dynamometer can be connected via its own cable 64, 64', 64" and coupling members 65, 65', 65" thereon to a universal counter-coupling member 67 in the housing of the evaluating device 12, the construction and mode of operation of which can be selected in the manner described above. In certain types of application it would also be possible to provide the evaluating device 12 with a connecting plate with counter-coupling members usable as desired for insertion of different matching coupling members of the dynamometers. In this way different types of coupling members could also to this extent be connected as desired to a universally usable evaluating device 12 without the individual coupling members having to be standardized beforehand.

According to the invention a data store 70, as shown by way of example in Fig. 5, is integrated into each of these different types of dynamometer 62 to 62", containing reference values, according to type, which are taken

into account together with the measuring signals in the evaluating unit 12 and displayed as required. Fig. 5 will serve to illustrate this in more detail.

Fig. 5 is a schematic illustration of a dynamometer of conventional construction. Two measuring strings 72, 73, separately secured at one end and tied together at the other end 74 at a particular angle, are arranged in the dynamometer housing 71. The weight to be measured 76, via a system of rods 75 on the one hand, and a reference weight 77 on the other, act on the connecting point 74, again at particular adjustable angles. A damper 78 is included in the system. The weight 76 is exerted by the object to be weighed 63 on a load pan 79, acting in accordance with the weight on a system of levers 80, only shown schematically, supported by the housing 71. Various means of effecting adjustments, not illustrated in detail, are provided for setting the dynamometer in the usual way, taking the zero point of the curvature error etc. of its measuring cell into account. The two connecting wires from the exciter magnets 81, 82 on the two measuring strings 72, 73 for sensing the measuring signals are connected to leads in the cable 64 attached to them and lead to the end coupling member 65 in the normal manner. In the present embodiment the data store 70 is located inside the housing 71 in a secure and not readily accessible place. The data store 70 contains reference values according to cell type which are called up together with the measuring signals by the evaluating device 12, illustrated in Fig. 4, which is to be connected. These reference values enable the evaluating device to ascertain whether, for the purpose of adjustment to the various types and sizes of weighing machine, the measuring signals received must be multiplicatively increased or decreased to ensure a correct weight reading in panel 56. For, depending on the conversion ratio and constructional details of the components, a particular measurement pulse can signify quite a different weight on one weighing machine compared with a similar pulse on a weighing machine of a different type. The data necessary for the relevant conversion are held in the data store 70 permanently connected to it. These constants are transmitted through the schematically illustrated wires 68 via the coupling member 65 to the evaluating device 12 where, in addition to the normal weight and price values, the particular reference values of the dynamometer 62 connected up can also be displayed in separate display fields 60, 61, as already explained for the previous embodiment. Further display fields can be provided in the evaluating device 12 which also indicate the exact type of dynamometer in the form of symbols or numbers which are also held as constants in the data store 70. Stored data of this type, which do not necessarily have to be included in the computations made by the evaluating device, may also be contained in the store, and made to appear on the display panel either on recall or permanently. Such data include the serial number of the weighing machine and its components, its test date, date of official approval, grade of the weighing machine, manufacturer's name, date of manufacture, type of weight-sensor, supply voltage and the like. Such data store 70 will of course also include the constants mentioned in connection with the above embodiment for correcting error, compensation and determination of individual weight values.

The embodiment illustrated in Fig. 5 also provides for measuring sensors 84 actuated by temperature (t), gravity acceleration (g) at the location of the weighing machine, and vibrations (b) affecting the housing 71, the sensors themselves transmitting correction data, on the basis of the values identified by them, via the wires 69 to the connected evaluating device, which then takes them into account in its calculations, together with the measuring signals from the weight determination. The constants for these corrections specific to this movement constitute an integral part of the dynamometer's data store 70 already mentioned several times. Correction data for the specific dynamic behaviour of the dynamometer are thus also taken into account there in the data store.

Instead of being in two physically separate housings, the dynamometer 11 and the evaluating device 12 could be accommodated in one overall housing around both parts. In this case the dynamometer 11 together with its matching data store 42 or 70 form a module for installation together in the overall housing.

CLAIMS

1. Weighing apparatus, comprising

a dynamometer actuated by the object being weighed, and capable of emitting electrical measuring signals indicative of the weight of the object,

and an electronic evaluating device linked to the dynamometer via an electrical connection for receiving said measuring signals, the evaluating device comprising

a calculator, and a read-out for the weight and/or price values determined or calculated by the calculator.

characterised in that

the dynamometer is fitted with a tamper-proof data store which holds constants characteristic of the dynamometer, said data store being linked to said electrical connection whereby, in addition to said measuring signals, the stored constants are also fed to the evaluating device.

2. Weighing apparatus according to claim 1, wherein the data store is incorporated into a coupling member connected to the dynamo-

meter and belonging to a two-part detachable coupling in a cable providing the electrical connection between dynamometer and evaluating device.

3. Weighing apparatus according to claims 1 or 2, wherein the constants stored are individual constants to predetermined static variations specific to the particular type of dynamometer construction such as errors in zero load and lineartiy, and correction values for the particular dynamometer, dynamic variations occurring at any particular moment of measurement such as errors in temperature and errors in weight caused by unwanted vibrations.

4. Weighing apparatus according to claim 1, wherein a standard evaluating device with universal display is connected to a number of different types of dynamometer and the data stores incorporated into the dynamometers contain characteristic reference values which enable the measurement pulses, which vary according to type, to be used uniformly in the same evaluating device.

5. Weighing apparatus according to claims 3 or 4, wherein the evaluating device has a display field which can be directly controlled by the constants stored in the dynamometer, in which field individual or specific data on quality and quantity relating to the particular dynamometer connected can be shown, such as construction, measuring range, sensitivity and performance class of the dynamometer.

6. Weighing apparatus according to one or or of claims 1 to 5, wherein the evaluating device is provided with a printer for visually readable weight or price data and/or machine-readable symbols.

7. Weighing apparatus as claimed in claim 1 of U.K. Patent Specification No. 1494302 wherein said constants are held in a data store which together with said transducer forms part of a dynamometer module, the values of the constants being specific to the particular transducer of the module, said data processing means and read-out means form part of an evaluating device module, and said modules are disengageabley electrically interconnected.

8. Weighing apparatus substantially as hereinbefore described with reference to any one of the embodiments.

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