United States Patent

[11] 3,587,315

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[21] Appl. No. 749,024
[22] Filed July 31, 1968
[45] Patented June 28, 1971
[73] Assignee United Gas Industries Limited, London, England.
[32] Priority Aug. 1, 1967
[33] Great Britain
[31] 35357/67

[54] SMALL UNIT CONSTRUCTION GAS METERS

12 Claims, 19 Drawing Figs.

[52] U.S. Cl. 73/268
[51] Int. Cl. G01f 3/20
[50] Field of Search 73/268, 267, 263, 264, 248, 249, 250; 91/178, 218, 325

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ABSTRACT: The specification discloses a multichamber gas meter having gas flow to and from the chambers controlled by a single slide valve which executes an oscillatory combined rotational and translational movement. A further aspect of the disclosure also relates to a gas meter body having two open chambers and formed as a two part moulded construction, the chambers being closed by diaphragms clamped to the body by covers defining the remaining chambers of the meter. The two parts of the body may be formed by moulding using dies converging from three directions, two of which directions are collinear.

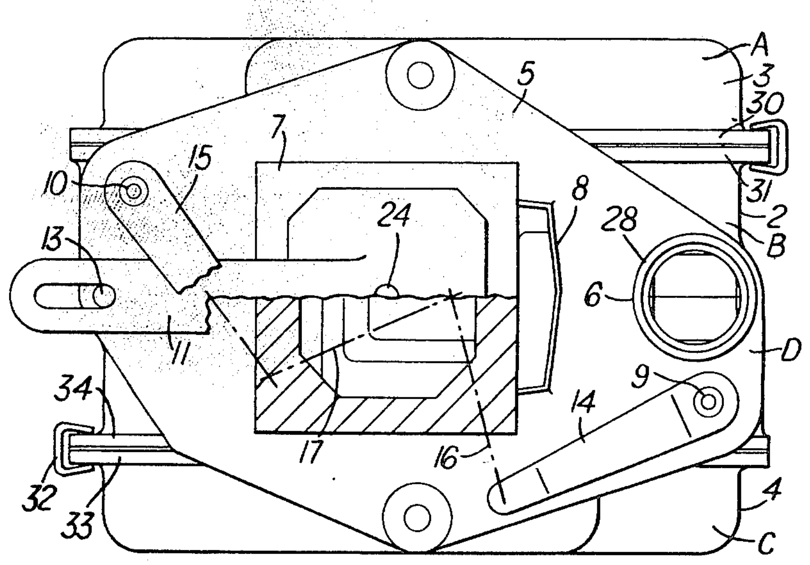

Fig. 1.

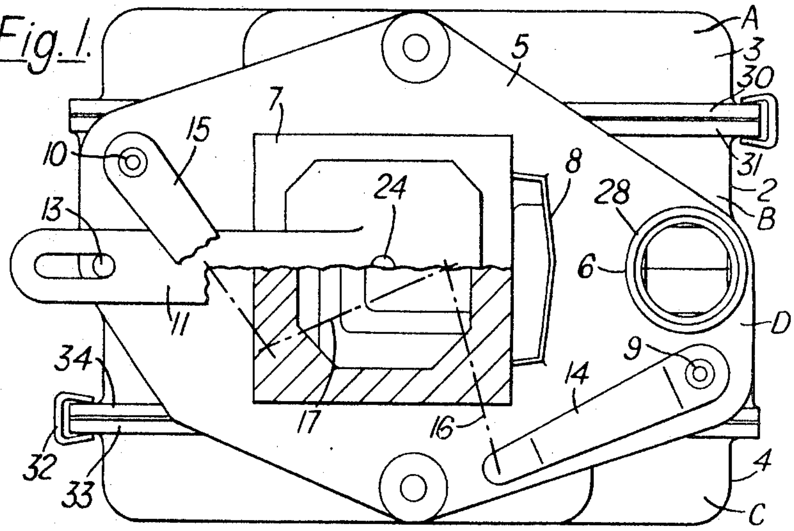

Fig. 8.

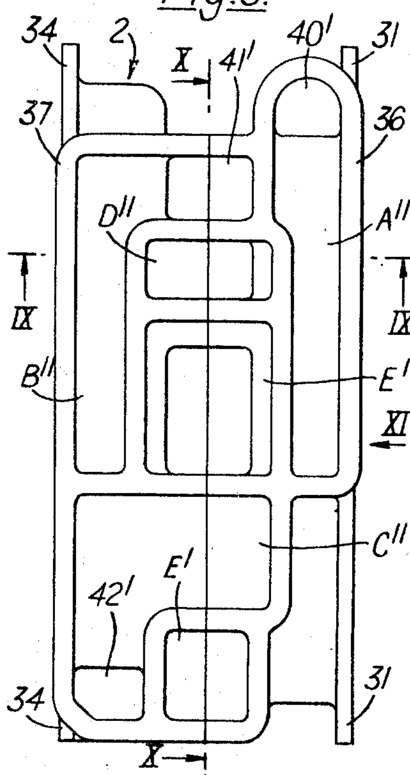

Fig. 9.

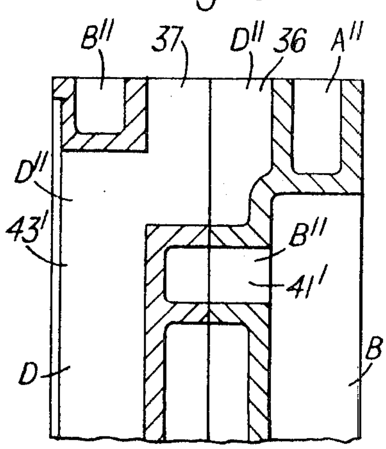

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Fig. 2.

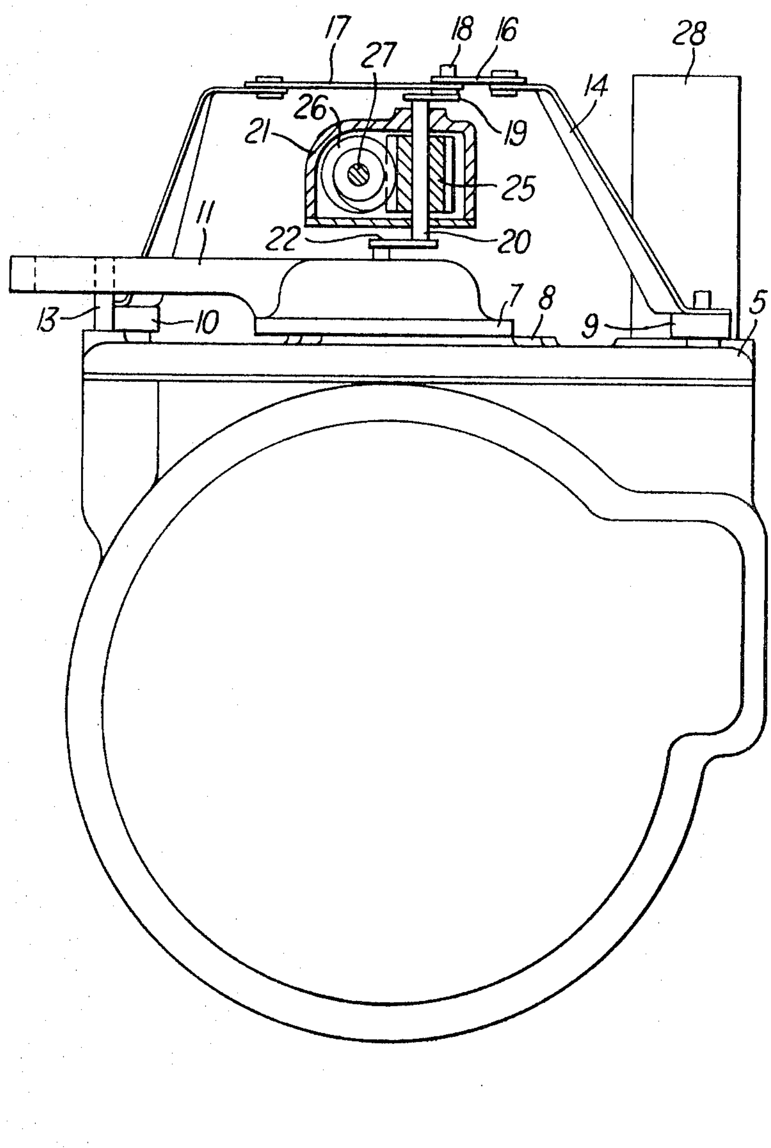

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Fig.3a.

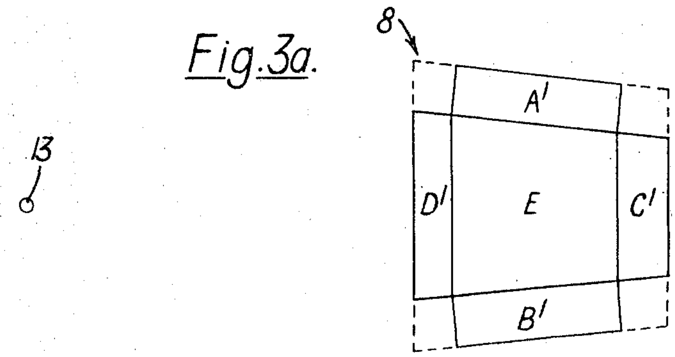

Fig.3b.

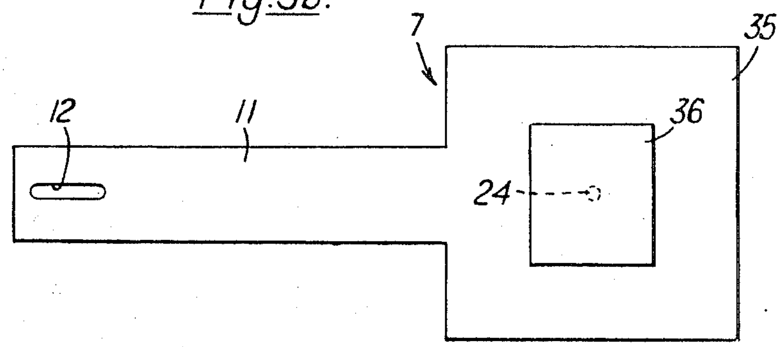

Fig.3c.

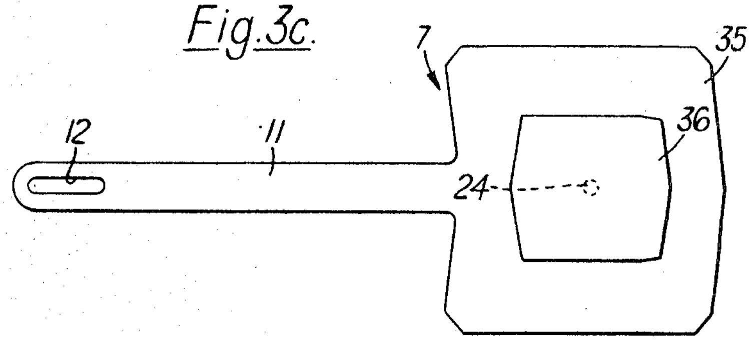

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Fig.4.

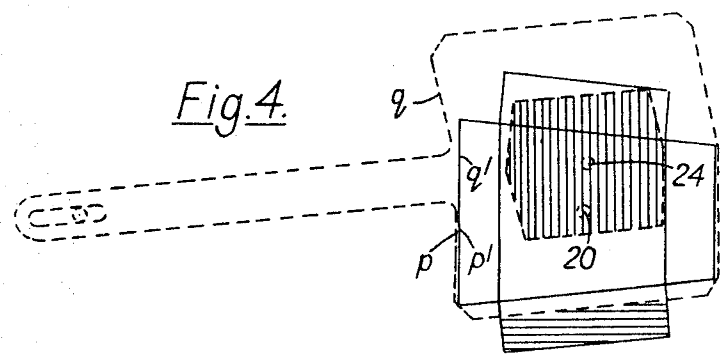


Fig.5.

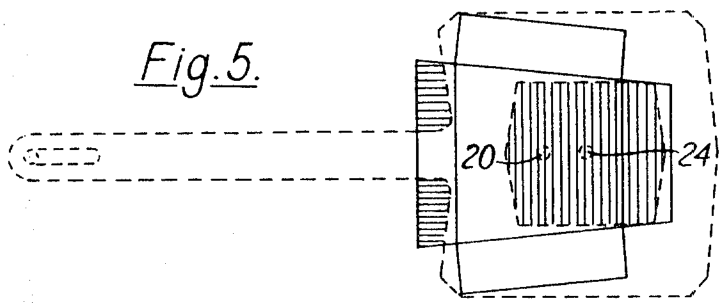


Fig.6.

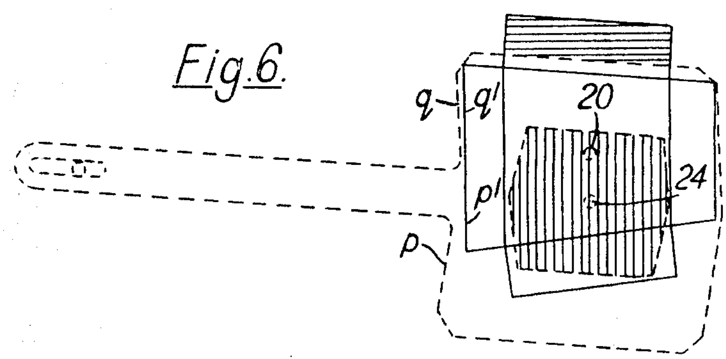
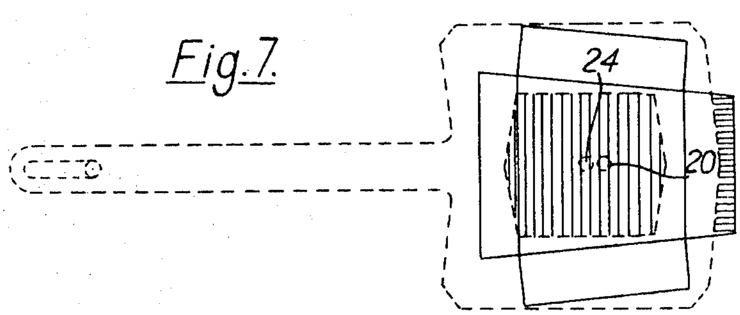


Fig.7.



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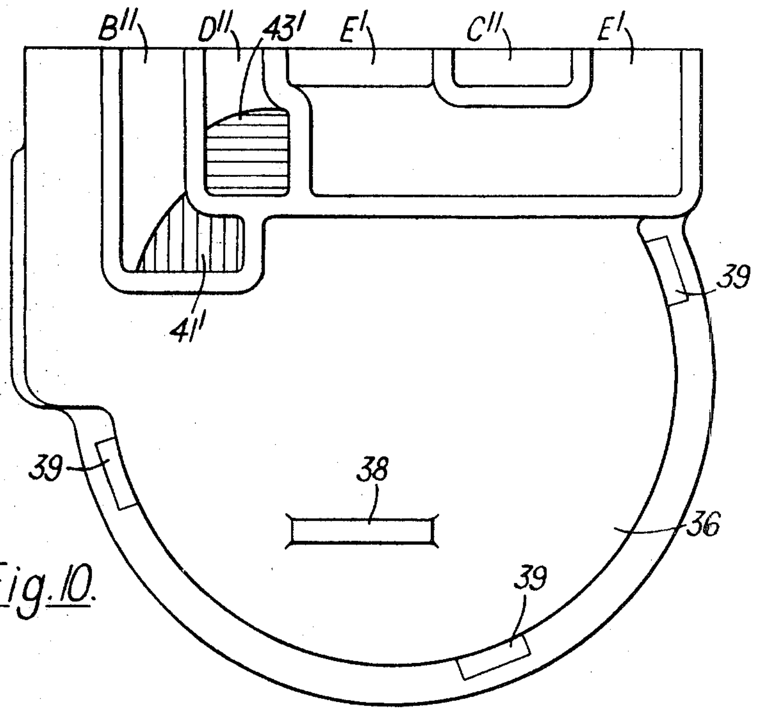

Fig.10.

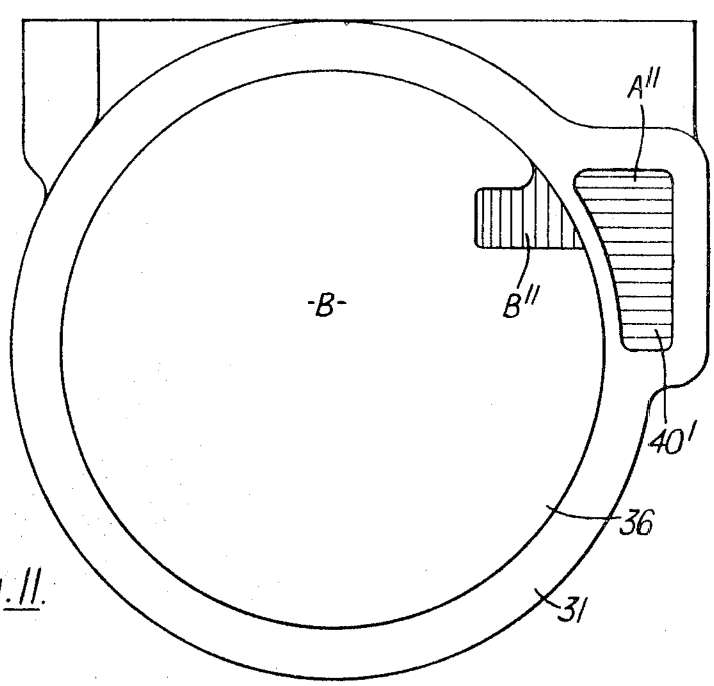

Fig.11.

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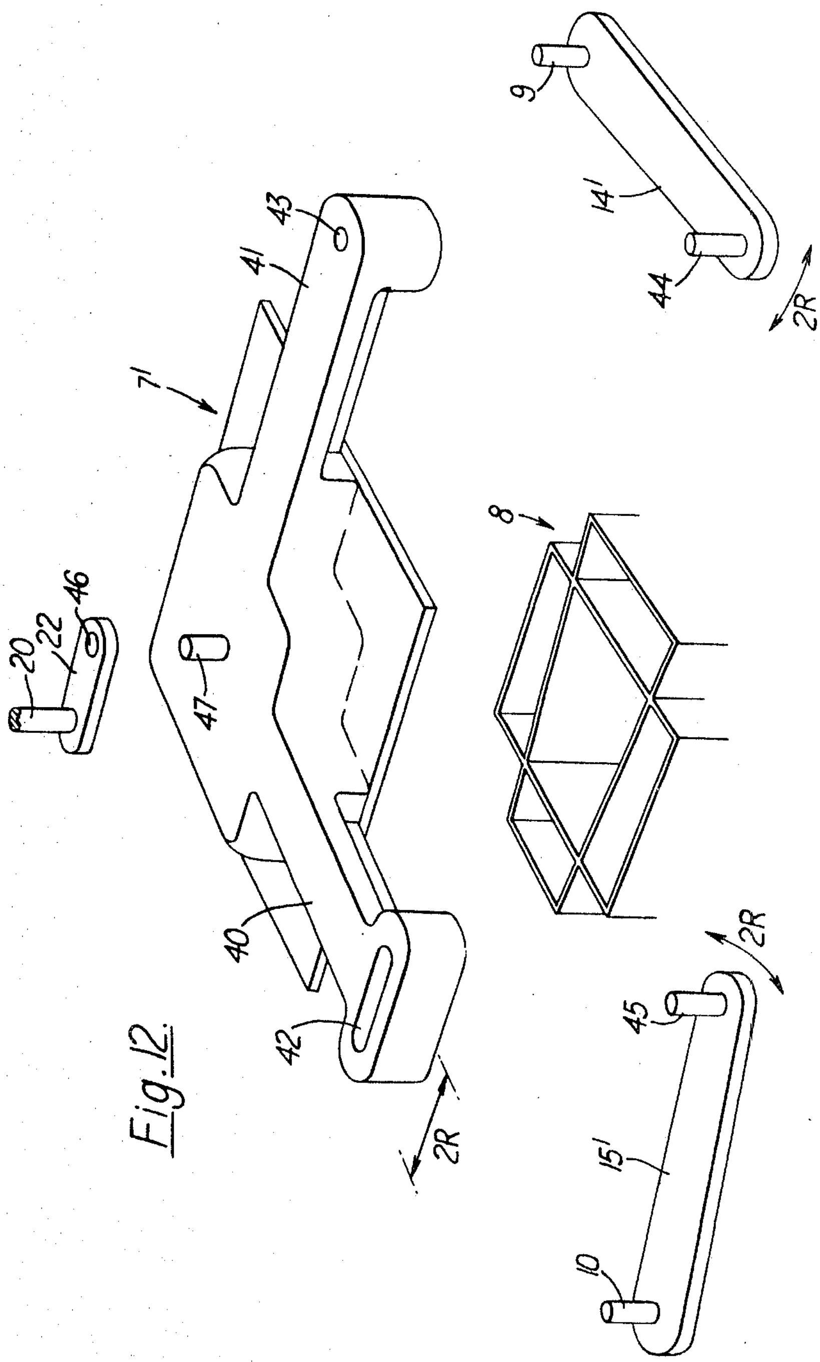

Fig. 12.

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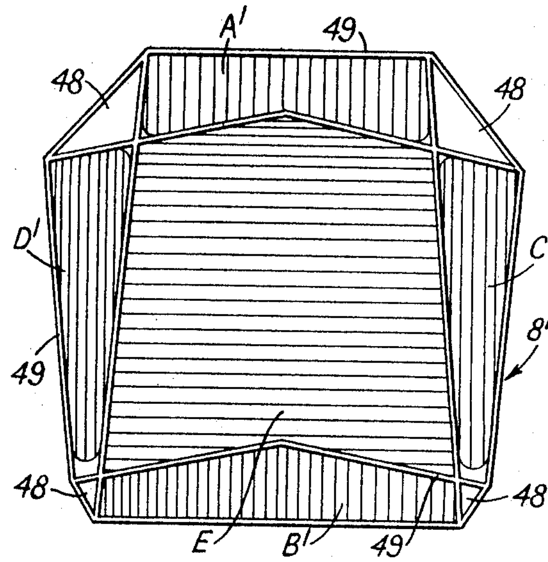

Fig. 13.

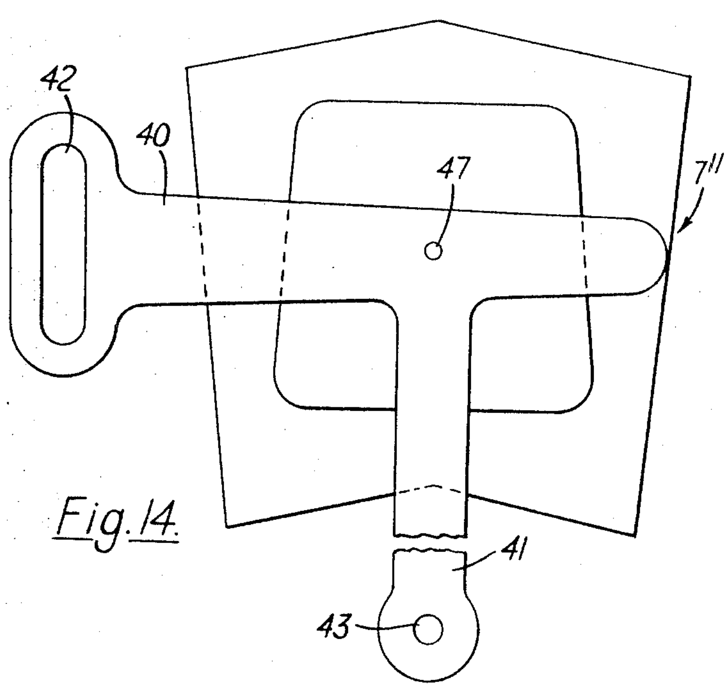

Fig. 14.

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Fig. 15.

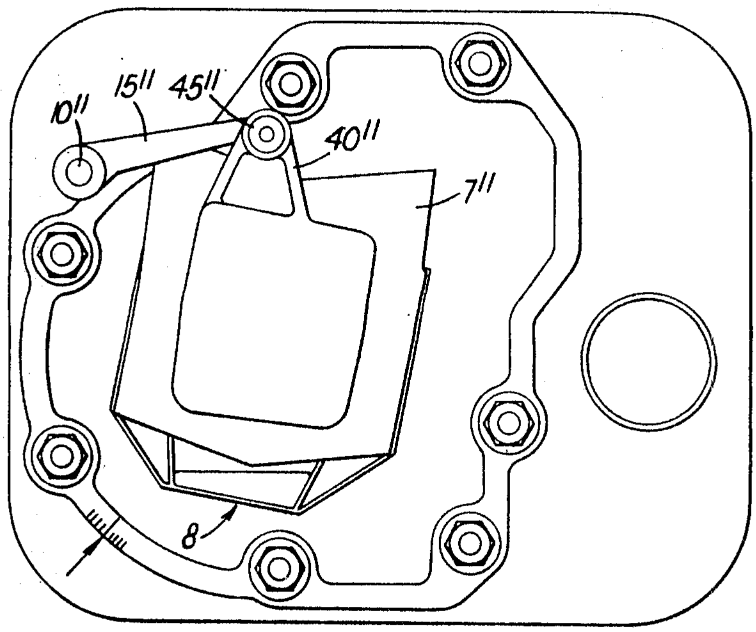

Fig. 17.

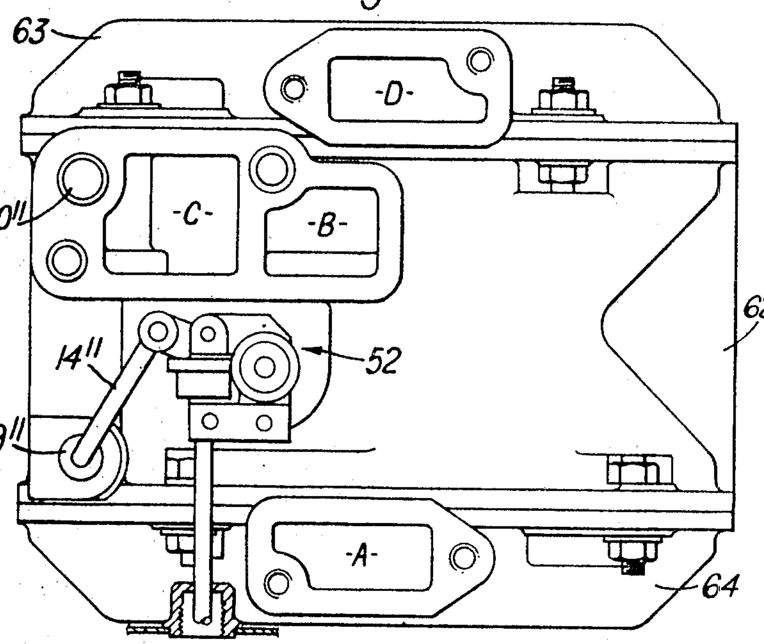

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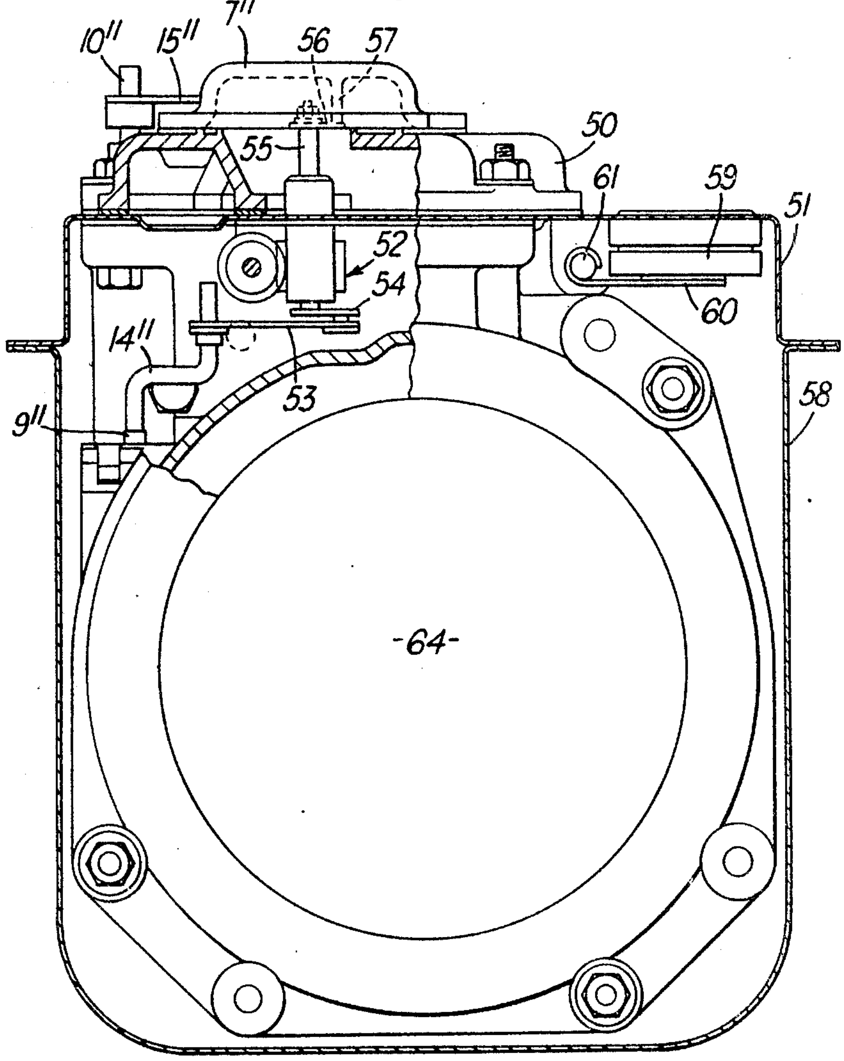
Fig. 16.



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SMALL UNIT CONSTRUCTION GAS METERS

The present invention relates to an improved dry gas meter.

It is an object of the present invention to provide a dry gas meter of the movable wall construction and which has an improved efficiency due to a reduction in valve drag with respect to the drag of a conventional rotary valve.

Conventional dry gas meters employ a pair of valves each cooperating with three valve ports opening into a gas inlet chamber. The three ports associated with each valve communicate with a pair of adjacent gas measuring chambers separated by one or more diaphragms, and an exhaust port to which each of the first two ports is selectively communicated by means of the associated valve. The valve construction must be such that at no time is the exhaust port exposed to the gas inlet chamber. Since two valves are used in the meter it follows that the valve drag and inertia of each valve and its associated linkage is duplicated.

According to one aspect of the present invention there is provided a movable wall gas meter including a single valve adapted to prevent at all times direct gas flow between inlet and exhaust, and arranged to execute a cycle in which each of the chamber ports of the meter is communicated to inlet for part of the cycle, to outlet for a further part of the cycle, and is sealed with respect to inlet, outlet and all other chamber ports, during the remainder of each cycle, said valve comprising a valve slide member which executes simultaneously oscillatory motion in both the rotational and translational modes in the same plane.

In one form of apparatus of the invention, the valve member comprises a domelike chamber having a peripheral seating portion, and the chamber ports are defined in a valve seating member over which the valve slide member slides. Preferably, the index drive shaft of the meter is connected to the valve slide member at a location which executes merely a circular motion about the axis of the index drive shaft, during operation of the valve slide member. Desirably, the inner and outer edges of the sliding surfaces of the valve are so shaped that, once during a cycle of operation of the valve, parts of each edge of the sliding surface of the valve slide member are in turn substantially coincident with and parallel to parts of the edges of associated ones of the chamber ports. In a four chamber meter the chamber ports may be arranged in pairs so that when one port of a pair is open to inlet the other port of the same pair is in communication with exhaust and during this time the ports of the other pair are closed to both inlet and exhaust.

Suitably a meter body including four chambers and the ducts communicating the chambers with their respective chamber ports of the valve is placed within a casing, the space within the casing and surrounding the body being exposed to measured exhausting gas and the index drive gear box being disposed within said space directly below the valve slide member and the chamber ports may be distributed around a centrally disposed exhaust port and wherein the inlet chamber of the meter is situated on one side of the valve assembly and the exhaust chamber is situated on the other side of the valve. Advantageously said valve is mounted above a top wall of said casing and is disposed within a top cover which is secured to said casing, the space beneath said top cover being exposed to inlet gas entering the meter and being sealed with respect to the space within said casing by means of the valve, an exhaust duct extending through the space within said top cover and communicating the space within said casing and a conduit discharging gas from said meter, said duct being associated with a shutoff valve for arresting flow of exhausting gas. The valve ports may be so arranged that the combination of the exhaust port and one pair of mutually opposite chamber ports, when taken together, forms a trapezium, and the combination of the exhaust port and the other pair of mutually opposite ports taken together forms a rectangle.

Conveniently at least, one top arm of the meter is connected directly to the valve slide member, and the other arm may be arranged to drive the index drive shaft by means of suitably

disposed links. In such a case one flag rod of the meter extends sealingly through said top wall of the casing and is provided with a top arm which is pivotally connected to the valve slide, the other flag rod of the meter terminating within the space bounded by said casing and being connected to a crank extending transversely of the lower end of a vertically disposed index drive shaft, by means of a suitable linkage, the underside of said valve slide being provided with a peg which engages with a crank extending transversely from the top end of said index drive shaft. Alternatively the index drive shaft may be driven by the top arms of the meter and may transmit motion to said location on the valve slide member.

A separate aspect of the invention provides a four chamber meter having a central body which contains two gas measuring chambers and all the ducting between at least some of the chambers and valve ports, the body comprising two separately formed moulded components, the other two chambers of the meter being provided by covers sealingly fastened to the meter body, said other chambers being separated from the first two chambers by the diaphragms of the meter. Conveniently, a top case of the meter may be sealingly joined to the top of said central body, and enclose the valve gear of the meter, there being no bottom case fitted to the meter. Preferably, each diaphragm is clamped between a face of the body and an adjacent face of one of said covers. Desirably, said two moulded components are formed of a synthetic plastics material, e.g., DELRIN. Conveniently, the bonding of the two components may be performed by ultrasonic welding. Alternatively, the meter body components may be formed of conventional materials such as phenolic resins and may be secured together by bolts, the joints being sealed either with gaskets or adhesives. Each of said chamber defining covers may be fastened to the main meter body by means of a flange on said cover engaging with a flange on said body, means being provided for holding said two flanges in engagement. Conveniently, the flanges may be held in engagement by means of clips, each clip being of a U-shape and comprising a bridge portion between a pair of limbs converging towards their free ends, said flanges being provided with locations at which the nonadjacent surfaces of the flanges, when assembled, have cross sections convergent away from the edges of the flanges. An alternative form of union between the two flanges comprises adhesively securing the flanges. Advantageously, the covers are made of a synthetic plastics material similar to that of the main meter body, and the covers are secured to the body by means of ultrasonic welding.

Advantageously the meter body, when assembled, has the ducting communicating the valve ports with the gas measuring chambers formed in its upper part, and has a pair of chamber defining shells extending from its lower part, each shell having a flange around its periphery and the two shells of a pair being disposed in back-to-back relation. Conveniently, the outer surface of each chamber defining shell is provided with a projecting rib, each shell being formed in one of the moulded parts of the meter body and said ribs being so dimensioned that, when the two parts of the meter body are joined together, the rib of one shell engages with and is weldable to the rib of the other shell.

Conveniently, each meter body moulding includes a portion of the ducting which extends vertically through the body portion and provides an aperture allowing through passage of the associated flag rod.

Desirably also the exhaust port comprises one end of the arm of a U-shaped passage formed in the central body, the other end of the passage communicating with an exhaust duct to convey the measured gases away from the meter.

The invention further provides a method of forming a gas meter body portion comprising separately moulding a pair of components containing ducting adapted to communicate the meter gas measuring chambers to the associated valve ports, each moulding operation being carried out by means of converging die parts from three directions two of which directions are directly opposed to one another along the same straight line, said two moulded components then being bonded together to form a single meter central body portion.

In order that the various aspects of the present invention may more fully be understood, the following description is given, merely by way of example, reference being made to the accompanying drawings, in which:

FIG. 1 is a top plan view, partly in section, of a dry gas meter illustrating certain aspects of the present invention;

FIG. 2 is a side elevational view, again partly in section, of the apparatus of FIG. 1;

FIG. 3A is a diagrammatic view of the valve grid of the meter of FIGS. 1 and 2;

FIGS. 3B and 3C are underneath plan views of alternative constructions for the valve slide;

FIGS. 4, 5, 6 and 7 are schematic views illustrating the relationship between the valve slide and valve grid in each of four positions during the movement of the valve slide;

FIG. 8 is a top plan view of the meter of FIG. 1 but with the index, top arms, valve gear and pan covers removed;

FIG. 9 is a sectional view taken on the line IX–IX of FIG. 8;

FIG. 10 is a sectional view taken on the line X–X of FIG. 8;

FIG. 11 is a side elevational view showing the apparatus of FIG. 8 when viewed along the direction of the arrow XI thereof;

FIG. 12 is a perspective, exploded view showing an alternative form of valve slide and driving arrangement;

FIG. 13 is a top plan view of a further form of valve grid;

FIG. 14 is a top plan view of a valve slide for use with the grid of FIG. 13;

FIG. 15 is a top plan view of a further embodiment of meter according to this invention;

FIG. 16 is a side view of the meter body of FIG. 15, shown partly in section and with the outline of the meter casing shown in full lines; and

FIG. 17 is a top plan view of the meter body shown in FIGS. 15 and 16, but with the valve mechanism removed.

Referring now to the drawings, and more particularly to FIGS. 1 and 2, the dry gas meter 1 is of the form comprising four chambers arranged in pairs, each pair of chambers being separated by a diaphragm. The main body 2 of the meter has a pair of pans 3 and 4 clamped one to each side, the pans 3 and 4 forming the housings of the outer chambers of the meter. The top of the meter is closed by a valve plate 5 having an exhaust duct aperture 6 formed therein. Selective filling and exhausting of the various chambers of the meter is performed by means of a slide valve comprising a slide 7 cooperating with a valve grid 8 formed in the valve plate 5. The valve drive mechanism in this apparatus is of the conventional form comprising flag rods 9 and 10 which are rotatably driven by flag arms connected to the diaphragms of the meter. An outwardly extending arm 11 of the valve slide 7 has a slot 12 through which an upstanding pin 13 of the valve plate 5 projects. Thus, the valve slide is permitted pivoting movement about the pin 13, and also sliding movement of the arm 11 longitudinally of itself within the limits defined by the ends of the slot 12 which engage pivot pin 13.

Particular reference to FIG. 2 will reveal the method by which the valve slide is driven from the flag rods. The flag rods 9 and 10 have top arms 14 and 15 respectively extending upwardly and radially outwardly therefrom. Tangent arms 16 and 17 (represented in FIG. 1 by means of dot-dash lines) are pivotally attached to the free ends of top arms 14 and 15, and are pivotally linked together on a crank pin 18 extending upwardly from a crank arm 19 on the upper end of the index drive shaft or crank spindle 20. Tangent arm 16 joins top arm 14 to crank pin 18, and tangent arm 17 join top arm 15 to the crank pin. The index takeoff gear housing 21 is supported by means not shown, and thus the index drive shaft 20 is constrained against lateral movement, and is merely permitted rotational movement about its own axis. The lower end of the index drive shaft 20 is provided with a further crank 22 which has a downwardly extending crank pin 23 attached to the free end thereof. This crank pin 23 is freely rotatably mounted in a recess 24 in the top surface of the valve slide 7 and thus the recess 24, by virtue of the constraint of the index drive shaft 20, is permitted a circular motion about the axis of the index drive shaft 20.

It will be seen, from a study of the pattern of movement of the valve slide 7, that in effect the slide executes a pattern of rotary motion similar to that followed by a conventional radial gas meter valve but that the movement is a compound of two oscillatory motions each one being based on one of a pair of orthogonal axes. Thus while the valve slide 7 executes a radial motion about the fixed pivot pin 13 the effect of the slot 12 slidable past the pivot pin 13 is similar to that of providing a radial motion symmetrical about an axis perpendicular to the axis of the motion about pin 13, namely perpendicular to the longitudinal axis of the arm 11 as viewed in FIG. 1. Clearly, such motion may take place in several different forms and, in the embodiment of FIGS. 1 and 2, the only constraint on this motion is that the recess 24 executes a continuous, purely circular motion about the axis of the index drive shaft 20. It will no doubt be appreciated that, due to the complex motion of the valve slide 7, the motion executed by every other individual point on the slide 7 will be continuous but will not necessarily be circular, and in fact will almost invariably be other than circular (e.g., elliptical).

The index drive takeoff gearing comprises a worm gear 25 fixed to the index drive shaft 20 and cooperating with a pinion 26 fixed on the index spindle 27.

The space above the valve plate 5 of FIGS. 1 and 2 will be enclosed within a gastight casing which is not shown, this casing forming the inlet chamber of the meter. The exhaust aperture 6 is provided with an upwardly extending exhaust duct 28 (see FIG. 2) which will extend sealingly through the abovementioned casing and communicate with the gas conduit leading to the distribution network, for example domestic gas piping and equipment. An inlet aperture in the nonillustrated casing will provide a mounting for the inlet duct of the meter, i.e., the gas main.

Since the drive arrangement of the flag rods 9 and 10 is of a conventional form, no detailed description is given hereinafter of the driving of these arms, but it will be understood that rotation of the crank pin 18 about the axis of the index drive shaft will follow from the oscillatory pivoting movement of the top arms 14 and 15 which results from movement of the diaphragms of the meter. Thus, the crank pin 23 is driven for rotation about the axis of index drive shaft 20 and the recess 24 in the top surface of valve slide 7 is caused to perform a similar circular motion.

During rotation of the crank pin 23, the circular motion of recess 24 will cause oscillatory pivotal movement of the valve slide 7 about pin 13, together with reciprocatory motion of the slide along the direction of the slot 12. This motion of the valve slide 7 will cause opening and closing of selective valve ports which are defined within the valve grid 8. As explained above, the inlet gas to the meter is contained within a top cover which is not shown and the gas enters through the valve grid 8 to the measuring chambers. In this particular construction of dry gas meter the four measuring chambers each have an inlet port defined in the valve grid 8, and a further port at the grid conveys the exhaust gas through a duct communicating with the exhaust aperture 6 and exhaust duct 28.

The four measuring chambers of the meter are formed as follows. The pan 3, which is clamped to the main block 2 by means of spring clips 29 holding together the flanges 30 and 31 on the pan and block respectively, encloses a first measuring chamber denoted by the letter A in the drawing. Two further chambers B and D are defined within the lower part of the meter block 2 but are separated from each other by a wall formed within the block. The chamber B is uppermost as viewed in FIG. 1. Finally, a chamber C is defined within the pan 4 which is held onto the block 2 by means of further spring clips 32 clamping flanges 33 and 34 together. The chambers A and B are separated from one another by a diaphragm which is clamped between the two flanges 30 and

31, and similarly the chambers C and D are separated by a further diaphragm clamped between flanges 33 and 34.

In order more clearly to illustrate the functioning of the valve slide 7 and grid 8, FIGS. 3A and 3B respectively, show somewhat diagrammatic representations of the valve grid 8 and the valve slide 7. FIG. 3A shows the general outline of the valve grid 8 shown in dotted lines, and the five ports shown in full lines. A′ and B′ denote two rectangular chamber ports and C′ and D′ denote two trapezoidal chamber ports, these reference letters being used to denote the connections between the chamber ports and the respective measuring chambers i.e., chamber A is associated with port A′ etc. The central trapezoidal port labeled E in FIG. 3A is the exhaust port which, as explained above, communicates with the exhaust duct 28. FIG. 3A also shows the fixed pin 13 which guides the motion of the valve slide 7 so as to induce limited rotational movement in the plane of the valve seating surface.

Turning now to FIG. 3B, there is shown one rather simplified form of the valve slide 7, showing the slide consisting of a longitudinally projecting arm 11 and a head 35, the head having a central aperture 36 formed therein. A slot 12 is formed at the free end of arm 11, as illustrated in FIG. 1. It should be pointed out that the view of FIG. 3B corresponds to an underneath plan view of the valve slide, the rectangular recess 36 comprising a domelike chamber which forms a transfer port for allowing the measured gas returning from each chamber to be transferred across into the centrally disposed exhaust port E. In this FIG., the area of head portion 35 surrounding the recess 36 constitutes the flat underneath face of the valve slide 7, this face sealingly cooperating with the valve grid 8.

The view of FIG. 3C, in which like reference numerals have been used for denoting like parts to those of FIG. 3B, shows an alternative form of valve slide 7 in which the head portion 35 and in particular the recess 36 has a different shape to that of FIG. 3B. Neither the head 35 nor the recess 36 now have rectangular walls, but instead the head 35 has the form of an irregular 10-sided polygon, and the recess 36 has the form of an irregular hexagon. The general dimensions of the two valve slides illustrated are substantially the same, i.e., the length of slot 12 is equal, the distance between the midpoint of slot 12 and the center of recess 36 is equal and the overall dimensions of the head portion 35 and recess 36 are similar, and in fact these two valve slides 7 are designed for use with the same valve grid. However, clearly the variation of the shapes of the components of the valve slide 7 of FIG. 3C has enabled a considerable reduction in the amount of material required, and hence has provided a valve slide of lighter weight and consequently of lower moments of inertia about the center of slot 12 and about the center of recess 36.

It will of course be appreciated that if the outer periphery of the valve slide 7 is unnecessarily large, then although each of the outer ports A′, B′, C′ and D′ will be adequately sealed with respect to the inlet space during at least three-fourths of the cycle of the valve slide 7, during the remaining period of the cycle of the slide 7 the degree of exposure of the individual port to the inlet space during an inlet stroke will be insufficient. In the extreme, a very large valve slide 7 will never open any of the outer ports to inlet and the meter will not function.

It is therefore important that, as described below with reference to FIGS. 4, 5, 6 and 7, the outer periphery of the seating surface of the valve slide 7 should be as small as possible consistent with the requirement for sealing each of the ports from the inlet space at all times other than an inlet cycle involving the particular port concerned.

Such reduction in size of the valve slide 7 of FIG. 3C has been accomplished by arranging that the outer periphery of the head is as small as possible while still ensuring that each port is opened to the inlet chamber only once during each revolution of the index drive shaft 20. This involves arranging each outer edge of the sealing face of the valve slide 7 so that when that edge is sealing off a port to the inlet chamber but opening it for transfer to the exhaust port it is substantially coincident with the edge of the port in question furtherest from the exhaust port. Similarly, the increase in area of the domelike chamber is achieved by ensuring that when a particular port is sealed with respect both to the inlet chamber and to the exhaust port, then the edge of the port nearest the exhaust port is substantially coincident with the nearest edge wall of the domelike chamber.

FIGS. 4 to 7 show the valve slide 7 in dotted lines superimposed on the valve grid 8 of FIG. 3A in each of the four principal positions of the valve slide during rotation of the crank pin 23 about the axis of index drive shaft 20. The index drive shaft 20 and the recess 24 which is formed in the top surface of the valve slide 7 are both illustrated in dotted lines in FIGS. 4 to 7 in order to illustrate the rotational motion of the crank pin 23 and recess 24 about the axis of the shaft 20.

Also in FIGS. 4 to 7, diagonal crosshatching has been used to denote the port area open to inlet, and vertical crosshatching denotes the area of exhaust port E and the respective port connected for transfer of gases thereto.

FIG. 4 shows the position in which port A′ is open to transfer measured gas to the exhaust port E, and the port B′ is open to the inlet chamber. Thus, the gas to be measured passes downwardly through the diagonally crosshatched area of port B′, into chamber B, and in so doing urges the diaphragm dividing chambers A and B to move towards chamber A so as to reduce the volume of chamber A. At the same time the already measured gas in chamber A is expelled by this movement of the diaphragm and passes up through port A′ and is transferred, via the domelike chamber 36, down into the exhaust port E.

After a quarter of a revolution of the crank pin 23 about shaft 20 to the FIG. 5 configuration the valve slide 7 is in a position where port D′ is open to inlet and port C′ is transferring to exhaust. Here again the inflowing gases through port D′ cause movement of the dividing diaphragm between chambers C and D so as to expel the already measured gas in chamber C and cause it to pass out through port C′ and be transferred to the exhaust port E.

A further quarter of a revolution of the crank pin 23, will result in the position shown in FIG. 6, in which port A′ is open to inlet and the gas in chamber B is thus expelled through port B′ to exhaust. Finally, in FIG. 7, port C′ is open to inlet and port D′ is discharging to exhaust.

Reference to FIGS. 4 and 6 will show that in one case (FIG. 4) the portion *p* of the outer periphery of the valve slide 7 is substantially coincident with the corresponding portion *p′* of the port D′. Similarly, in the other case (FIG. 6) the portion *q* of the periphery of the valve slide 7 is substantially coincident with the corresponding portion *q′* of the port B′. The result of this characteristic is that, as shown in FIG. 5, during the inlet cycle involving port D′, the port D′ is substantially completely exposed to inlet but is nevertheless sealed with respect both to the exhaust port E′ and to each of the adjacent chamber ports A′ and B′. A similar situation exists with regard to each of the other ports and with regard to each other portion of the periphery of the valve slide 7.

The above description of the movement of the valve slide 7 is somewhat simplified, since there will be a tendency for the two diaphragms to be at their extremes of movement at the same time. It is therefore necessary to stagger the operation of the diaphragms so that when one is at an extremity of its movement the other is still approaching or already departing from its midstroke position. As is well known in the construction of dry gas meters, some form of timing adjustment has normally to be incorporated, this adjustment being possible for example by traversing the pin 13 across the valve plate in a direction transverse to the particular orientation of arm 11 in FIG. 7. In this manner it can ensured that while one diaphragm is at an extremity of movement the position of the other one, which is approaching or departing from its respective midpoint is adjustable in order that the setting may be chosen to be appropriate for the meter to function in a continuous manner. Clearly, once the correct timing setting has been found it will be possible either to clamp the pin 13 in the appropriate position, or to construct all similar gas meters with the pins 13 integrally formed with the plate 5 but fixed in the appropriate position. The efficiency of such an integral pin form of meter will depend upon the degree of accuracy of the manufacture of the flag rods and arms, the top arms, the valve slide and the valve plate.

FIGS. 8 to 11 provide illustrations of the main block 2 of the meter. The block 2 is formed of a pair of components 36 and 37 which are separately formed, such as by moulding, but which may be joined by any suitable manner. Advantageously, the block parts 36 and 37 are formed of a synthetic plastics material such as that commonly known as "Delrin" in which case a particularly suitable method of joining the two block parts together comprises ultrasonic welding to join the two components 36 and 37. However, the block parts could be made of phenolic resin and bolted together, a sealant such as adhesive or a gasket being applied to the joint. The top plan view of FIG. 8 shows the block 2 when the valve plate 5 and all the valve gear, flag rods and index drive have been removed. In order to illustrate the connection between the valve ports A', B', C' and D' and the respective chambers A, B, C and D the ducting formed in the block has been given similar referencing A'', B'', C'' and D''. Similarly, the exhaust passage which communicates exhaust port E with the exhaust duct 28 has been reference E' in this view.

FIG. 8 shows clearly that ducting A'' communicates, by means of a ducting portion 40', with chamber A which would be formed when the pan 3 and its diaphragm are placed in position. Similarly, ducting B'' is shown to communicate between the approximate position of port B' (i.e., to the left of exhaust passage E' in FIG. 8) and the chamber B formed in the block portion 36. This is by means of a ducting portion 41' which passes downwardly into the block 2 and thence back under the ducting D'' and into chamber B. The construction of this ducting portion 41' is shown clearly with reference also to FIG. 9. The ducting C'' is shown in FIG. 8 to communicate between the approximate position of port C' and the chamber C, via a ducting port 42'. For understanding of the construction of ducting D'', reference must be made to both FIGS. 8 and 9 where it can be seen, from the approximate position of the port D', that a ducting part 43' passes downwardly into the chamber D illustrated in FIG. 9. Finally, the exhaust passage E' passes downwardly under the ducting C'' and up to a location adjacent the approximate position of exhaust aperture 6 in the valve plate 5.

The configuration of the various ducting parts is best appreciated with reference to the sectional view of FIG. 9 taken on the line IX–IX of FIG. 8, and to the sectional view of FIG. 10 taken on the line X–X of FIG. 8.

The sectional view of FIG. 10 and the side elevational view of FIG. 11 illustrate, between them, the chamber B defined within the block part 36. FIG. 11 shows a view looking into the chamber and FIG. 10 shows the view as seen from the opposite direction looking towards the outer face of the chamber in the form a shell-like structure formed in the bottom part of block portion 36. In FIG. 10, a projecting rib 38 is shown formed in the rear face of the block part 36, this rib 38 being welded to a similarly formed corresponding rib on block part 37. The welding of the two ribs gives a stronger construction and reinforces the combination of the two measuring chambers B and D.

The clips 29 of FIG. 1 are adapted to engage in suitably formed locations 39 of FIG. 10 and, as can be seen in FIG. 1, the clips 29 are each of U-shape, having a bridge portion joining a pair of limbs converging towards their free ends. The clip locations 39 are formed with a slight reentrant angle, i.e., the cross section of the flanges 30 and 31 at a clip location 39 is such that the thickness at the edge of the flange is greater than the thickness inboard of the edge. Thus, the clips 29 are prevented from inadvertent release from the flanges and a secure joint is achieved. Alternatively, the pans 3 and 4 may be fastened to the block 2 by means of adhesive, welding, or any other suitable joining process.

In the meter illustrated, in which the two flanges are held together by an external clip, the diaphragms of the meter are held between each pair of engaging flanges 30, 31 or 33, 34. By pressing the two flanges of a pair firmly into engagement, with the diaphragm clamped therebetween, the assembly provides a pair of gastight measuring chambers separated by a single diaphragm.

The diaphragm may be of genuine leather, or any suitable plastics material which is able to withstand the corrosive constituents of the gas being measured. This construction of the meter block 2 is particularly advantageous since the provision of the pair of ribs 38 which may be welded together and which may form a spacer between the two chambers enables the considerable reduction to be achieved in the quantity of material used for moulding the block. Known meters of the block type construction have the chambers formed entirely within the block, rather than having ducting arranged within a block and then the chambers formed as shells projecting from the block. The strength of the shell construction described is clearly improved by the presence of the two welded ribs 38.

Furthermore, the "crossover" configuration of the ducting in the block enables the drive to the valve slide to comprise a single-throw crank whereas, with a more conventional layout of ducting, i.e., where port A' is adjacent port B' instead of being diametrically opposite to it, a double-throw crank arrangement would be required in order to maintain the correct sequence of operation of the meter. As can be seen clearly from FIGS. 8 to 11, the particular construction of the two-part meter block used enables the various ducts to be formed in the moulding relatively simply and cheaply. Clearly, the various parts of the ducting, although separated by walls formed in the mouldings 36 and 37, are only gastightly separated from each other when the valve plate 5 is in position. Thus, it is important that suitable sealing means be included between the top face of the block 2 and the lower face of the valve plate 5 in order to seal the various parts of the ducting with respect to each other.

The side elevational view of FIG. 11 shows the opening of the ducting B'' into the chamber B, and also shows the opening of ducting part 40' of ducting A'' conveying the gas to and from chamber A when the pan 3 and diaphragm are in place.

Although not specifically illustrated in the accompanying drawings one of the two flag arms would be positioned within chamber A, and will have one end pivotally attached to the diaphragm separating the chambers A and B. The other end of the arm will be fixed to the lower end of the associated flag rod 10 which will be situated within the vertical part of ducting A''. The opening of the ducting part 40' which is visible in FIG. 11 therefore provides the location for the lower end of flag rod 10 and the associated flag arm. From its lower end the flag arm 10 will extend upwardly through the vertical part of ducting portion 40' (as viewed in plan in FIG. 8) and will then pass through the valve plate 5 via a suitable stuffing box or other sealing device. The location of flag rod 9 with associated flag arm on the meter block component 37 will be substantially the same as the arrangement just described.

As described above it is possible for the pans 3 and 4 to be attached to the meter block 2 by means of adhesives or welding. Where a weld for example an ultrasonic welding joint has been used, there will be no danger of tampering with the meter and possibly removing either of the pans 3 and 4 and thus there will be no requirement for a bottom case to be provided for the meter. In this form of meter it will be possible for the valve plate 5 to be extended laterally slightly and for the top cover of the meter (not shown in the accompanying drawings) to be fastened to the valve plate with a gastight seal between these two components. Thus the construction of the meter will be considerably simplified since there will now no longer be a requirement to provide a bottom case component which hitherto had to be provided inter alia to prevent tampering the the pan cover joints and possible leakage of the measuring chambers thereby.

A further, more preferable form of valve slide is shown at 7' in FIG. 12. This FIG. is a perspective exploded view showing a valve grid 8 similar to that described with reference to FIGS. 4, 5, 6 and 7. In this particular form of meter however, the tangent cranks have been eliminated from the apparatus and the top arms 14' and 15' are connected directly to the valve slide 7'.

The valve slide 7' has a pair of mutually perpendicular arms 40 and 41 having a slot 42 and hole 43 respectively at their free ends. Top arm 14' has an upwardly extending pivot pin 44 at its free end, such pin 44 engaging in the hole 43 at the end of arm 41. A similar pivot pin 45 is provided at the free end of top arm 15' and engages in the slot 42 of arm 40. Once again the index drive shaft 20 has a crank 22 at its lower end, and is restrained against lateral movement by means of the mounting of the index takeoff gear casing 21. However, in this embodiment the crank 22 has an aperture 46 which freely rotatably receives a pin 47 integrally formed on the upper face of the valve 7'. In this manner the pin 47 is only permitted rotational movement along a circular orbit centered on the axis of index drive shaft 20. In other words, the assembly of top arms 14' and 15' together with the valve slide 7' has replaced the linkage 14, 15, 16, 17, 18 and 19 of the construction illustrated in FIGS. 1 and 2. The two top arms 14' and 15' are again fixed to the upper ends of their respective flag rods 9 and 10 as can be seen from FIG. 12. During operation of the meter, each top arm is free to rotate through a small angular distance such that the respective pivot pin 44 or 45 is allowed to move between two positions separated by a distance denoted 2R in FIG. 12. The radius of the orbit of pin 47 about index drive shaft 20 (i.e., the spacing between index drive shaft 20 and aperture 46 of crank 22) is equal to the distance R, and the slot 42 has a length again equal to 2R.

As top arm 15' rotates about the axis of its associated flag rod 10 the pin 45 moves backwards and forwards along a path 2R in length. This causes pivoting of the valve slide 7' about hole 43, together with a certain amount of movement of pin 45 longitudinally of slot 42. Similarly rotation of top arm 14' about the flag rod 9 causes pin 44 to move along a path 2R in length, this in turn moving the hole 43 along a similar path, causing pin 45 to traverse a slot 42. The particular configuration of the valve slide 7', the flag rods 9 and 10 and the top arms 14' and 15' provides for substantially a purely rotational movement of the pin 47 to be produced. However, due to the constraint of index drive shaft 20 and the fixed radius of crank 22 this motion can only be a purely circular orbiting movement, and thereby will result in rotation of the index drive shaft 20 and of the index itself. During such rotational motion the various ports of the valve grid 8 are communicated to inlet and to transfer with exhaust, thereby maintaining the appropriate diaphragm movement necessary for rotation of the flag rods.

The "double-radial" motion described above with reference to FIGS. 3*a*, 3*b*, and 3*c*, can more clearly be seen to be followed in the embodiment of FIG. 12. The oscillation of top arm 15' about flag rod 10 would cause the valve slide 7' to execute a radial movement about pivot pin 44 on the other top arm 14'. However, the pin 44 is itself moving, due to the oscillatory pivotal motion of the second top arm 14' about flag rod 9, and is also giving rise to a "radial" oscillating movement of the valve slide 7 about pivot pin 45 on the first top arm 15'.

Although the valve grid and valve slides disclosed in the foregoing description have been so shaped that the valve grid is of relatively simple form and the valve slide of relatively complex form with the advantage that the material used for the valve slide is substantially reduced, it is possible for the valve grid to be of complex construction, and for the valve slide to be relatively simple. Thus, instead of each port A', B', C', D' and E' being of quadrilateral construction it is envisaged that the various ports should consist of irregular polygons having more than four sides.

FIG. 13 illustrates, in plan, an alternative form of valve grid 8'', and FIG. 14 shows a top plan view of the valve slide 7'' suitable for use with the grid 8''. The configurations of the grid and slide illustrated in these FIGS. have been arrived at by a process similar to that described above with reference to FIGS. 3*a*, 3*b* and 3*c*.

The reference numeral 48 denotes blind ports which are provided so that the outer periphery of the valve grid 8'' encloses a sufficiently large area to ensure that at no time during the movement of the slide 7'' between its four principal positions is the exhaust port F communicated to the inlet chamber. The grid 8'' can be seen as comprising a plurality of upstanding walls 49 enclosing a central port area E, the four ports A', B', C' and D' and the four blind ports 48. The crosshatched areas of the ports A', B', C', D' and E represent the apertures in the valve plate 5.

FIG. 15 shows a top plan view of yet a further embodiment of slide valve according to the present invention. It can be seen that one top arm 15'' is connected to the valve slide 7'' by means of a pivot pin 45'' on the free end of the top arm 15'' and engaging in a suitable aperture at the end of an arm 40'' of the valve slide.

This particular embodiment of meter is shown in side elevational partly sectional view in FIG. 16 in which part of the meter is shown as a pure section taken down the center of the device and the remainder is shown as an elevational view of the meter body disposed within the outer casing which is shown in outline only.

FIG. 17 illustrates a top plan view of the parts of the meter remaining after the valve seating member 50 and top cover 51 of the meter have been removed, leaving the gear box 52 exposed. From FIGS. 16 and 17 it can be seen that the other top arm 14'' of the meter is disposed at the same end of the meter as top arm 15'' shown in FIG. 15 and is connected by a link 53, to a crank 54 fixed to and extending transversely of the index drive shaft 55.

As shown clearly in FIG. 16, the top end of the index drive shaft 55 is located directly under the valve slide 7'' and is provided with a transversely extending crank 56 having a hole near its free end through which extends a pin 57 formed integrally with and extending downwardly from the valve slide 7''. Thus, during rotation of the index drive shaft 55, the valve slide 7'' will be caused to execute a motion in which the pin 57 moves in a circular orbit around the axis of drive shaft 55.

Clearly, although the two top arms 14'' and 16'' have their upper ends at different levels within the device, the linkage comprising link 53, crank 54, index drive shaft 55, crank 56, pin 57 and arm 40'' provides a direct mechanical connection between the two top arms 14'' and 15''. By appropriate arrangement of the crank angles between the various components of this linkage the meter may be constructed to have a desired timing setting and to operate continuously during passage of gas therethrough. Although the device of FIGS. 15, 16 and 17 only has one point of direct attachment to a top arm, namely pin 45'' on arm 40'', the motion is nevertheless constrained to be identical to that executed by the embodiment of FIG. 12 since the top arm 15'' executes an oscillating motion about the associated flag rod 10'' and the pin 57 of valve slide 7'' executes a clearly rotary motion about the axis of the index drive shaft 55, similar to the motion of pin 47 about the axis of index drive shaft 20 in FIG. 12. Thus, here again a "double-radial" type of movement ensues.

Although the embodiment of FIGS. 15, 16 and 17 has a slightly different ducting arrangement to that described in detail above with reference to FIGS. 8 to 11, it will be appreciated that the principle of operation is the same and that therefore no detailed description of the chamber construction is required, in order to explain the action of the slide valve 7''. It should be understood that the valve seating member 50 communicates each of the valve ducts A, B, C and D with the relevant ports of the valve base, the exhaust passage being formed by the space confined within the top cover 51 and the bottom cover 58 comprising the casing of the meter. Exhaust gas from the meter passes upwardly out of this space through a prepayment shutoff valve of housing 59 once the prepayment shutoff valve flap 60 has been pivoted in the clockwise sense about its pivot pin 61. The inlet chamber of the meter is confined within a suitable outer top cover (not shown) which will be sealingly fastened above the top cover 51, and an exhaust stack (not shown) extends upwardly from the prepayment shutoff valve housing 59 through the outer top cover in order to convey the measured gas away to one or more appliances.

The construction of gas meter illustrated in FIGS. 15, 16 and 17 is considerably smaller than the conventional meter having the same swept volume, since the index gear box 52 has now been placed below the valve mechanism of the meter, within the exhaust space confined by the outer casing 51 and 58. Furthermore, the two flag rods 9'' and 10'' of the meter have now been placed at the same end of the meter rather than being diagonally oppositely placed as shown in the embodiment of FIGS. 1 to 12, and thus the field of movement of the top arms and associated linkage has been considerably reduced with respect to the conventional meter. Clearly, by placing the flag rods 9'' and 10'' so close together it has been made possible to reduce the depth of the meter (the vertical extent as viewed in FIGS. 15 and 17).

It has been found that the power index factor for the meter valve can be maintained at just below the value of 1.2. The calculation to determine the power index factor is specified in British Standards No. 4161. Known single valve meters employ rotary valves and have power index factors considerably in excess of 1.2, the maximum limit permissible under B.S. No. 4161 part 3 relating to the quality of dry gas meters. Although known twin valve radial motion meters have power index factors of below 1.2, the linkage arrangement associated with such valves is extremely complicated and cumbersome and in view of the duplication of valves and associated linkages, construction of such a meter is expensive and time consuming. The present invention therefore provides a dry gas meter having a valve arrangement which is particularly cheap to manufacture and yet efficient in its operation.

It will be appreciated that the particular embodiment of gas meter illustrated in FIGS. 15 to 17 will be able to employ a purely circular diaphragm fixed between the central body 62 and the two pan covers 63 and 64. This configuration of the diaphragm is particularly well illustrated in the side elevational view of FIG. 16 in which the pan cover 64 can be seen to be circular and may thus be sealed against the central body 62 by means of a circular diaphragm clamped between a sealing face of the pan cover 64 and an adjacent sealing face of the central body 62.

Thus, when fitting the diaphragm to the meter prior to assembly of the pan cover 64 to the meter body 62, it will be possible to rotate the diaphragm to a position in which there is a minimum amount of crinkling or creasing of the diaphragm before the pan cover is clamped to the meter body thereby ensuring that a good seal is obtained. Such careful positioning of the diaphragm is not possible in the construction illustrated in FIGS. 10 and 11 since there, as shown particularly well in FIG. 11, the diaphragm will be provided with an "ear" in order to provide a continuous seal around the periphery of the passage 40. Thus, the diaphragm must be carefully positioned to seal the passage 40 and no further rearrangement is possible when the ear on the diaphragm is in register with the passage 40, even if severe crinkling or creasing is found.

A further advantage of the purely circular diaphragm construction is that there will be no need to manufacture separate left-hand and right-hand diaphragms since the diameters of the two pan covers 63 and 64 are the same and thus identically shaped and dimensioned diaphragms may be used with each of them.

Although the embodiment of FIGS. 1 to 11 incorporates an arrangement in which the index drive shaft or crank spindle is driven independently from the flag rods and then the valve slide member 7 is driven from the index drive shaft, it will be seen that the embodiments of FIGS. 12 to 17 illustrate a particularly advantageous construction in which the crank spindle or index drive shaft is driven from the flag rods by means of a linkage which includes the valve slide member 7' or 7''. Clearly, by incorporating the valve slide 7' or 7'' in the linkage between the flag rods and the index drive shaft, a saving in the number of components of the meter will have been obtained, thereby simplifying construction and enabling cost of production to be reduced.

We claim:

1. A movable wall gas meter comprising an inlet duct, an outlet duct and a plurality of measuring chambers and a single valve having ports communicating with the chambers, a valve slide member cooperable with said ports, means for subjecting the valve slide member to motion responsive to movement of the movable wall resulting from the passage of gas through the meter, and means for constraining the valve slide member to execute said motion as simultaneous oscillatory motion in both the rotational and translational modes in the same plane whereby, during a cycle of movement of the valve slide member, each of the ports is connected to said inlet duct for part of the cycle, to said outlet duct for a further part of the cycle, and is sealed with respect to inlet duct, outlet duct and all other of said ports during the remainder of said cycle.

2. A gas meter as set forth in claim 1, and wherein said valve slide member comprises a dome having a peripheral seating portion, and wherein said valve further includes a valve seating member defining said valve ports and over which the valve slide member slides.

3. A gas meter as set forth in claim 2, wherein the valve seating member includes exhaust port means and four chamber port means, and the valve slide member and the valve seating member have cooperating sliding surfaces each provided with inner and outer edges consisting of rectilinear portions, the exhaust port means having trapezoidally arranged inner and outer edges, the parallel edges of which lie adjacent to trapezoidal chamber port means and the nonparallel edges of which lie adjacent to respective rectangular chamber port means, said valve slide member inner edges being hexagonally arranged and valve slide member outer edges being decagonally arranged so that once during a cycle of operation of the valve slide member each rectilinear portion of the edges of the sliding surface of the valve slide member is in turn substantially coincident with and parallel to a rectilinear portion of the edges of associated ones of said exhaust port and chamber port means.

4. A gas meter as set forth in claim 1, wherein said constraining means constrains the valve slide member at two points to execute said simultaneous rotational and translational movement.

5. A gas meter as set forth in claim 4, and including an index drive shaft connected to said valve slide member, one of said constrained points being located at the point of connection between said index drive shaft and said valve slide member.

6. A gas meter as set forth in claim 1, and including a meter body having four measuring chambers and ducts communicating the chambers with their respective ports; a casing containing said body, and an index drive gear box disposed outside the body but within the casing, said casing being exposed to measured exhausting gas.

7. A gas meter as set forth in claim 1, wherein the chamber ports are distributed around a centrally disposed exhaust port said inlet duct communicating with one side of the valve and said outlet duct communicating with said exhaust port and located on the other side of the valve.

8. A gas meter as set forth in claim 1, wherein the valve includes a valve seating member in which said ports are disposed, said valve seating member having formed therein a plurality of passages extending therethrough, individual passages communicating respective chambers to their associated parts.

9. A gas meter as set forth in claim 1, and including a pair of flag rods each provided with a transversely extending top arm, at least one of said top arms being connected to said valve slide member.

10. A gas meter as set forth in claim 9, wherein both said top arms are connected to the valve slide member, said meter including an index gear box drive shaft driven by the said valve slide member.

11. A gas meter as set forth in claim 9, which includes an index gear box drive shaft and wherein one top arm is connected directly to the said valve slide member and the other top arm is drivingly connected to said index gear box drive shaft, means being provided for drivingly connecting said drive shaft and said valve slide member.

12. A gas meter as set forth in claim 1, and including a casing surrounding the chambers, a pair of flag rods having top arms, one of the flag rods extending sealingly through said casing and the other flag rod terminating within the space bounded by said casing, and a linkage connecting the two top arms, said linkage including as one member thereof the valve slide member.