Jan. 5, 1960 F. J. MARKEY 2,919,712

FLUID JET EDGE POSITION DETECTOR

Filed May 25, 1956 3 Sheets-Sheet 1

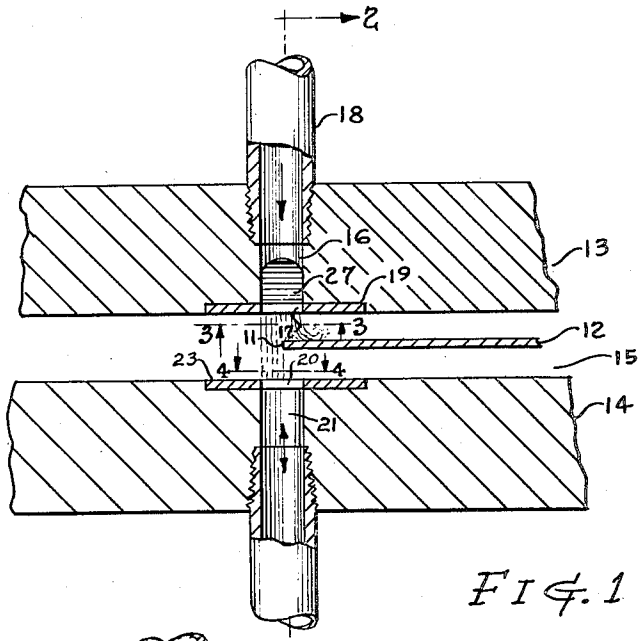


FIG. 1

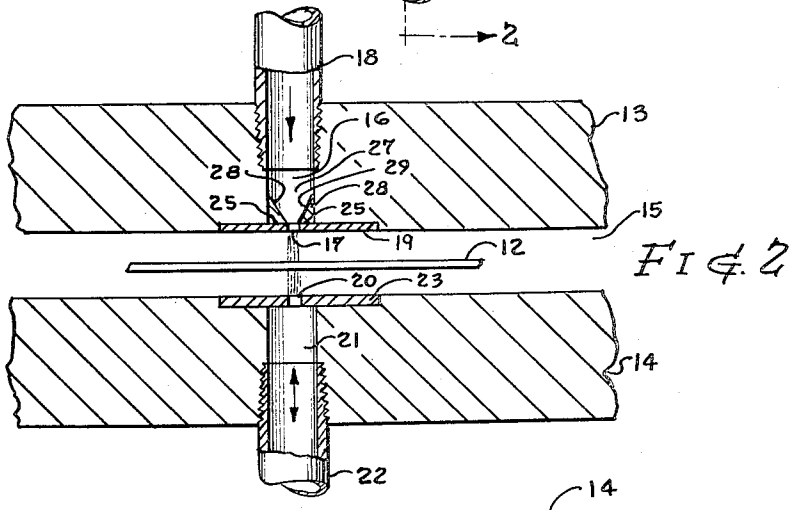


FIG. 2

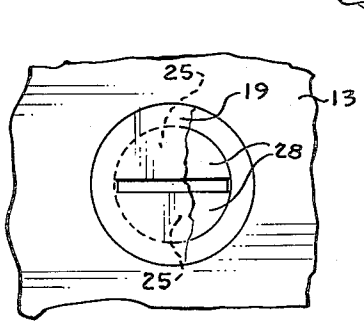


FIG. 3

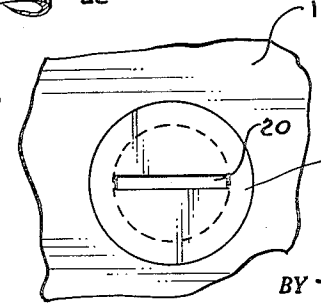


FIG. 4

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FLUID JET EDGE POSITION DETECTOR

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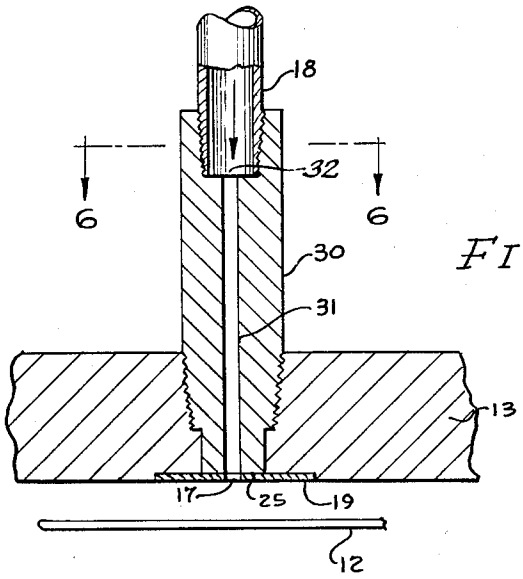


FIG. 5

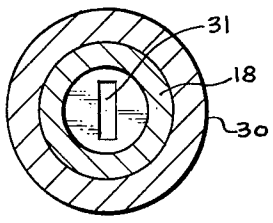


FIG. 6

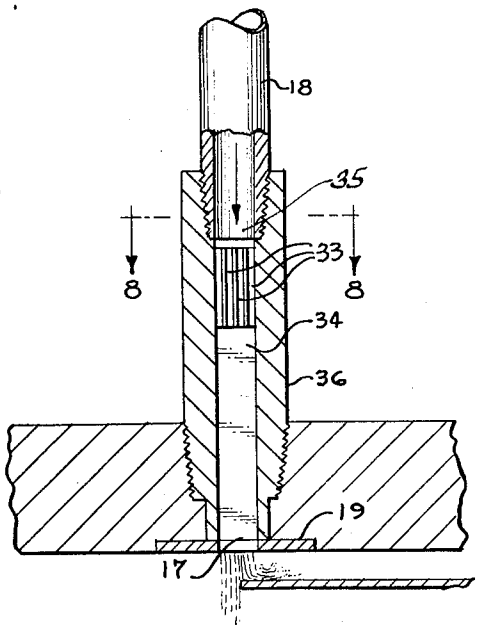


FIG. 7

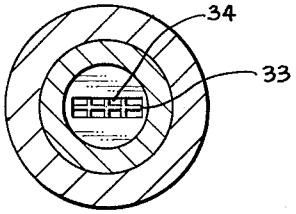


FIG. 8

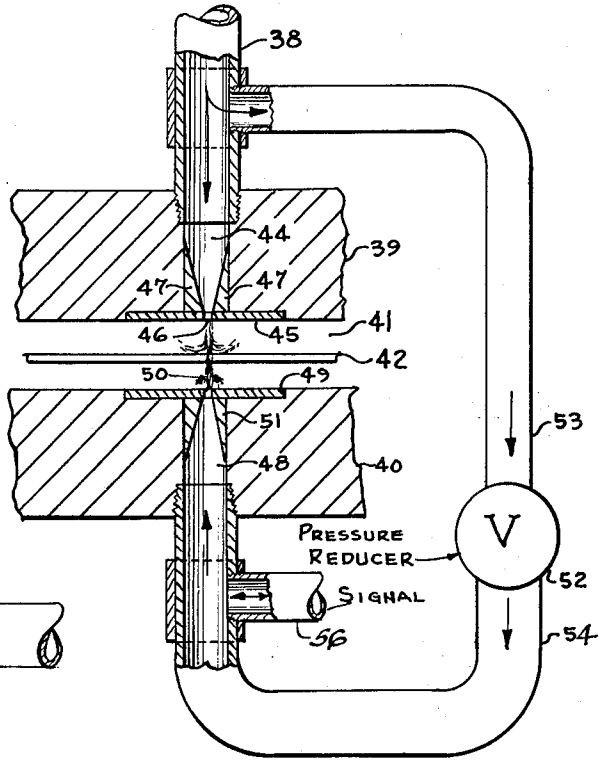
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FLUID JET EDGE POSITION DETECTOR

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FIG. 9



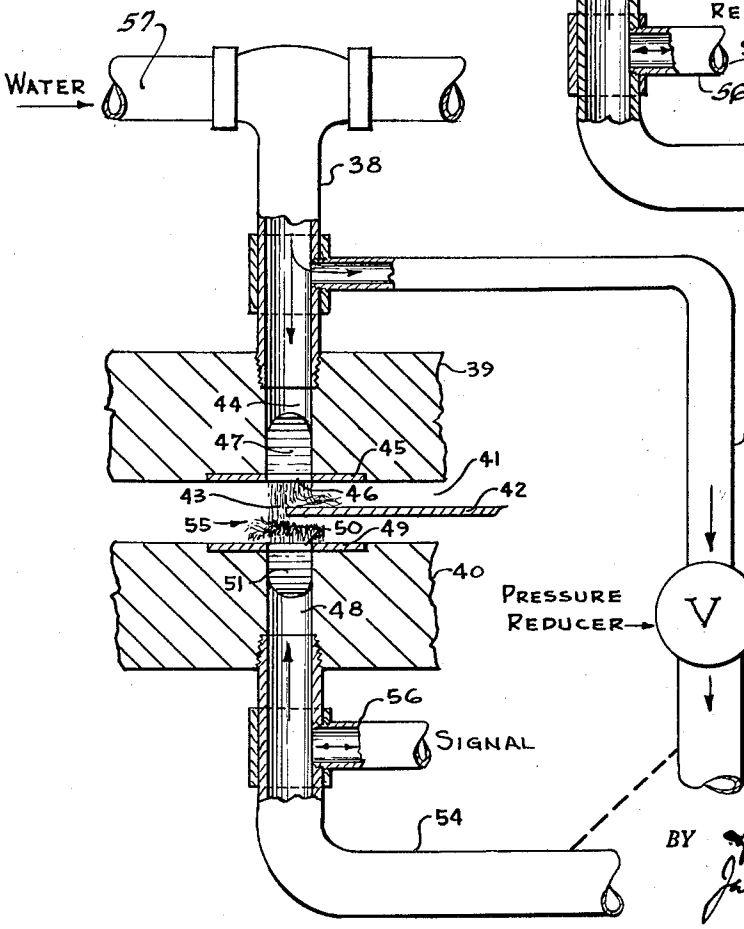


FIG. 10

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FLUID JET EDGE POSITION DETECTOR

Frank J. Markey, Hammond, Ind., assignor to GPE Controls, Inc., a corporation of Illinois

Application May 25, 1956, Serial No. 587,330

5 Claims. (Cl. 137—83)

The present invention relates to sensing of the lateral position of an edge of a thin body, typified by the edge of a strip, web or plate, and development of a signal the magnitude of which varies continuously and substantially in linear correspondence to degree of lateral positional change of the edge. More specifically the invention relates to edge position detectors wherein the position of the edge is sensed, and the signal developed by a jet of fluid that is directed toward and partly past the edge, the cross sectional area of the portion of the fluid jet that passes the edge being varied proportionally with the lateral position of the edge, and the kinetic energy of the passed portion serving to develop a pressure in a signal pressure chamber of constant volume located beyond the edge from the jet delivery device, and having a port that faces the jet path.

As heretofore developed, in such devices both liquid and gas have been used as the jet fluid, and it has been the universal practice to so deliver the jet that the portion thereof that is unintercepted by the body the edge of which is undergoing position-sensing, reaches the port of the signal pressure chamber, the kinetic energy of that jet portion serving to develop the signal pressure the magnitude of which represents the position of the edge. A refinement, proposed for such detectors for purposes of preventing entry and lodgement of foreign material in the signal pressure chamber and its port, and for preventing development of negative pressure conditions in the signal chamber and connected signal transmission system, is disclosed and claimed by my application for United States Patent, Serial No. 529,737, now Patent No. 2,794,444, dated June 4, 1957, and comprises pressurizing the signal system and chamber by constantly delivering fluid to it, whereby entry of the edge-detecting jet to the signal pressure chamber is opposed by a counter pressure and a counter flow, which tend to prevent carrying of foreign matter into the chamber. Furthermore, a part of that prior proposal resides in elimination of internal shoulders from the pressure signal developing chamber and port structure, whereby foreign material that does enter, as during a sudden increase in the cross sectional area of the jet portion reaching the chamber port, is more readily ejected.

During the course of commercial development and exploitation of such devices it has been proposed to select the characteristic of signal pressure magnitude variation to degree of edge position change by shaping the jet discharge orifice and receiver port in directions extended transverse to the longitudinal extent of the edge. For example, it has become customary, for the purpose of rendering signal pressure magnitude variation linearly responsive to distance of edge shift, to deliver the jet through a slot-like discharge orifice, and to employ a similar slot-like signal pressure chamber port, the two being aligned and in register and respectively positioned to opposite sides of the region wherein the sensed edge is located, the longer dimensions of the slot-like apertures being disposed transverse to the longitudinal extent of such edge.

While in theory the employment of shaped jet discharge aperture and pressure chamber ports will produce corresponding characteristics of signal pressure magnitude variation in response to change in sensed edge position, such correspondence has not been accomplished with completely satisfactory accuracy. This invention is based on the realization that the structure that has been used to discharge the jet has been so arranged that the jet is of highly unstable form, tending to twist and waver, and at least to some extent to scatter or expand. This characteristic appears to result from turbulence generated in the stream of fluid delivered to the discharge aperture, and a primary concept of the invention is that of so delivering the stream, that is, so arranging the conduit structure through which it is delivered to the discharge orifice, as to eliminate or minimize turbulence, thereby providing a jet that is highly stable in the form imparted to it by the discharge orifice, and consequently very markedly improving accuracy of a selected characteristic relationship between magnitude of the pressure developed by the jet and the lateral position of the edge of a body that partly intercepts the jet. In such detectors it has been conventional practice to deliver the jet-forming fluid through a bore in a structural member and, for convenience of manufacture and assembly, it has been conventional to make that bore cylindrical and of cross sectional area corresponding to that of a supply conduit that is to be coupled to it at one end, the opposite end being covered or masked by a plate having therein a discharge orifice of the selected shape and overlying a portion of the bore. Investigation has shown that the shoulders formed at the inner surface of the plate and overlying a cylindrical bore have created turbulence in the fluid stream immediately adjacent the discharge orifice, which condition has been reflected by the twisting, wavering and generally unstable characteristics described and which are typical of a fluid jet discharged into air through a restriction in the path of flow to the discharge orifice. The present invention contemplates substantial elimination of turbulence that results from sudden alteration of the shape and reduction of the cross section of the flowing stream by structure presenting internal shoulders and/or pockets, by providing the flow path to the orifice with an arrangement that will produce smooth and regular flow immediately adjacent and through the orifice, whereby the jet is rendered highly stable, and retains the cross section imparted to it by the discharge orifice.

A corollary or refinement of the invention, which is made possible and practical by stabilizing the jet in the manner described, relates to an extension of the desirable practice of pressurizing the pressure signal system to prevent interference with signal development by foreign matter. The highly stable detector jet makes it possible to deliver fluid to the signal system at such pressure and volume rate as to insure constant fluid discharge from the pressure chamber port under all conditions, the fluid so discharged meeting, at a location spaced between the chamber port and the sensed edge, the jet portion passed by that edge, and the signal pressure being developed by transmission, or reflection, of the kinetic energy of the unintercepted jet portion through the stream of fluid discharged from the chamber port. Such constant fluid discharge from the signal system completely precludes entry of foreign matter, in fact, prevents approach of such matter to the immediate vicinity of the port, even though such material may be flying toward it with considerable momentum. Accurate signal generation in this

manner is made possible by the highly stable character of the jet and the portion thereof that passes by the sensed edge.

A primary object of the invention is provision of a novel arrangement for supplying fluid to the jet discharge orifice of a detector of the kind in question, whereby a highly stable jet is produced with resulting high degree of accuracy of the response characteristic of the device selected by the configuration of the jet discharge orifice.

Another object is the provision in a detector of the kind in question of a novel arrangement for rendering highly linear the signal pressure variation response to edge position change.

Still another object is the provision of a novel method and novel apparatus for sensing the position of an edge and developing a signal pressure of corresponding magnitude by oppositely directed streams of fluid meeting in an open space, one of which streams is partly intercepted by the marginal portion of the body the edge of which is sensed, and the signal pressure being developed through the second stream.

In the accompanying drawings:

Fig. 1 is a fragmentary section through an edge position detector and showing one form of the invention.

Fig. 2 is a section on line 2—2 of Fig. 1.

Fig. 3 is a section on line 3—3 of Fig. 1.

Fig. 4 is a section on line 4—4 of Fig. 1.

Fig. 5 is a section of the jet delivery device of an edge position detector showing another form of the invention.

Fig. 6 is a section on line 6—6 of Fig. 5.

Fig. 7 is a section similar to Fig. 5, showing another form of the invention.

Fig. 8 is a section on line 8—8 of Fig. 7.

Fig. 9 is a partial section of an edge position detector arranged in accordance with the invention to develop a signal by streams of fluid meeting in open air.

Fig. 10 is a transverse section of the arrangement shown in Fig. 9.

First describing Figs. 1 to 4, an assembly for sensing the edge 11 of a body 12, and developing a signal pressure of magnitude corresponding to lateral position of the edge, comprises a pair of supporting structures 13, 14 that are spaced apart to provide a throat 15 for entry of bodies, such as 12. One structure 13 is provided with a passage 16 for delivery of fluid to a jet discharge orifice 17. For convenience of manufacture and ready assembly with a supply pipe 18, passage 16 conventionally is circular in cross section, and discharge orifice 17 is formed in a plate 19 fixed to the surface of structure 13, masking the end of passage 16 and with aperture 17 overlying a portion of the end area thereof.

Facing discharge orifice 17 and registered therewith across throat 15 is a port 20 that communicates with a pressure signal developing chamber 21, conveniently a bore in structure 14 and with which a signal pressure transmission pipe 22 is coupled. Conveniently port 20 is an opening in a plate 23 fixed to structure 14 and overlying chamber 21. In accordance with known practice, a jet of fluid supplied through pipe 18 and discharged through orifice 17, is more or less intercepted by the marginal portion of body 12 adjacent edge 11, depending on the lateral position of the latter. The portion of the jet that passes edge 11 affords a measure of the edge position, and kinetic energy of the jet portion so passed is used to develop in chamber 21 a signal pressure, the magnitude of which is determined by the position of edge 11.

As seen in Figs. 1 to 4, jet discharge orifice 17 and port 20 are in the form of elongate, parallel sided slots, with their longer dimensions disposed transverse to edge 11, this configuration being adopted with the object of providing a linear relationship between degree of position change of edge 11 and magnitude of resultant change of pressure developed in chamber 21.

Referring to Figs. 2 and 3, it will be seen that to each

of the longer sides of discharge orifice 17, portions 25 of the inner surface of plate 19 overlie corresponding portions of the area of passage 16, and form internal shoulders and pockets at each side of the inner opening of orifice 17. Experiment with water jets has shown that such shoulders and surface areas generate substantial eddying and turbulence in the fluid stream flowing through such an orifice as 17, and that the jet discharged from such an arrangement is highly and irregularly unstable. Such instability takes the form of wavering and irregular twisting of the jet, and irregular variation of its cross sectional size and shape, these effects increasing with increasing distance from the discharge orifice, and being so substantial at the location of the sensed edge and beyond, as to very seriously diminish accuracy of the relationship between magnitude of pressure developed in chamber 21 and lateral position of the sensed edge. In accordance with the basic concept of the invention, the flow passage supplying the discharge orifice is provided with a configuration productive of smooth, regular and turbulent-free flow of the fluid to and through the discharge orifice. Primarily such configuration is arranged to eliminate turbulence in the stream as it is discharged, particularly turbulence developed by internal shoulders formed by plate surfaces such as 25 overlying portions of the supply passage in immediate adjacency to the discharge orifice.

Prevention of turbulence development, and elimination or reduction of turbulence generated at some upstream location are well known in practices relating to flow of fluids through enclosed flow passages, and any of a number of well known expedients that is convenient and practical in an edge position detector of the type in question can be used for stabilizing the edge detecting jet in accordance with the invention. In Figs. 1 and 2, a smoothly tapered throat 27 is provided for changing the cross section of the fluid stream from that of pipe 18 and passage 16 to that of orifice 17 without generation of turbulence. Such throat conveniently is provided by a pair of inserts 28 the outer surfaces of which match corresponding portions of the surface of passage 16, while end surfaces closely abut the inner plate surfaces 25, and opposed inclined surfaces 29 define throat 27.

Figs. 5 and 6 show another type of turbulence-reducing arrangement, comprising an elongate member 30 having a passage 31 of cross section matching discharge orifice 17 and of sufficient length from the turbulence generating coupling point at 32 between conduit 18 and member 30 to permit the stream flowing through passage 31 to straighten out prior to discharge from orifice 17. Progressive elimination of turbulence by flow through a smooth surfaced passage of uniform cross section is a well known characteristic of flowing streams.

Figs. 7 and 8 show employment of another well known form of flow-straightening device, comprising a series of straight and parallel vanes 33 disposed in a fluid flow passage 34 that matches the shape of discharge orifice 17 and that extends between the turbulence generating coupling 35 between supply pipe 18 and a member 36 enclosing passage 34 at which coupling the stream section is changed from that of the passage enclosed by pipe 18 to that corresponding to the shape of orifice 17.

Supply of fluid to a jet discharge orifice through a flow path arranged to prevent development of or to eliminate or materially reduce turbulence markedly improves the response characteristic of a device of the kind in question. In situations wherein the jet fluid is water, the effect of turbulence reduction in stabilizing the jet is readily visible, the jet consistently maintaining a single position, as distinguished from a wavering, twisting or other irregularly varying condition that occurs in more conventional devices, and maintaining the cross sectional form imparted to it throughout its extent across a throat such as 15. While a gaseous fluid, such as air, tends to expand upon discharge in jet form, the stability of gaseous fluid jets that are commonly employed in such

devices is markedly improved by turbulence elimination, reduction or prevention devices such as those shown. Specifically, in a detector provided with jet discharge orifices and signal pressure chamber ports defined between parallel edges disposed transverse to the longitudinal extent of edges to be sensed, linearity of signal pressure change response to edge position change is markedly improved. Because of the absence of tendency of a water jet to expand after discharge, response linearity of water jet detectors is exceptionally high, and productive of very superior results in situations permitting their employment. Automatic guiding of travelling webs under control of the signal pressure developed by such a detector employing a water jet, such as in maintaining the wire of a paper machine in a proper path, and in certain types of metal sheet, plate and strip handling, has been very highly successful.

Figs. 9 and 10 disclose an edge position detector employing the invention as disclosed above in an arrangement providing positive protection of the signal system against entry of foreign matter. In certain situations moving sheets, plates, strips, or webs which are guided by relay mechanism controlled by an edge position detector, throw off material, which may be of practically any mass or condition, as air borne lint, adhesive, impregnant or coating material, pulp, metal scale or other particles, and so on. If light and air borne, such material tends to be carried toward the pressure chamber port and frequently is carried into the signal system by the jet. Other materials may be carried to the port region by inertia, and they may lodge across or in it, or, if adhesive or plastic, may build up in and around the port, more or less blocking it. Such conditions necessitate frequent shutdown for cleaning. As previously proposed, fluid has been fed to the signal system at a volume rate and pressure tending to prevent entry of foreign material, particularly of light, air borne character and/or to eject any such material that does, under certain conditions, enter the system. That proposal, however, contemplated development of the signal pressure by impingement upon the chamber port of the jet portion passed by the sensed edge. For that reason, the rate and pressure of fluid supply to the signal system have been limited to insure jet impingement on the chamber port, and such limitation, although the practice has proven highly effective in eliminating adverse effects of air-borne material, has rendered the practice only partly effective or wholly ineffective to protect against flying heavier materials approaching the chamber port with considerable velocity and momentum.

It has been discovered that stabilization of the jet, as described above, renders it possible and practical to discharge fluid from the pressure signal chamber at sufficient rate and pressure to provide positive protection against heavier flying material, and to develop the signal pressure by reflection through the stream of fluid so discharged and meeting the jet portion passed by the sensed edge at a location spaced outwardly from the pressure signal chamber port. This arrangement has proven particularly effective in water jet systems wherein water is supplied to the signal system at pressure and rate productive of the described mode of operation. The system of Figs. 9 and 10 is exemplary of an arrangement so operating.

In this system water for forming the jet and for discharge from the signal system is supplied at suitable pressure through a conduit **38**. The detector assembly comprises an upper jet-discharge member **39** and a lower signal pressure developing member **40**, spaced apart to provide a throat **41** for reception of a body **42** the edge **43** of which is to be sensed for development of a position-representing signal pressure. The jet forming subassembly is like that of Fig. 1, conduit **38** being connected to a passage **44** in member **39**, covered by a plate **45** pierced by the jet discharge and forming aperture **46**, again shown as of slot form. Turbulence prevention and jet stabilization are accomplished by tapered throat-forming inserts **47** arranged in the end region of passage **44** immediately adjacent the inner surface of plate **45**, for turbulent-free changing of the stream cross section from that of passage **44** to the shape of discharge orifice **46**.

The pressure signal-developing subassembly comprises a bore **48** in member **40**, which serves as the pressure signal-development chamber, the end of which is masked by a plate **49** having therein the chamber port **50** which corresponds in shape and size to orifice **46** and is registered with it. Preferably, though not necessarily, chamber **48** is furnished with tapered throat-forming inserts **51** that smoothly merge with the chamber walls and the margins of port **50**. Water from conduit **38** is supplied to chamber **48** at a pressure determined by setting of a pressure reducing valve **52** in a branch supply line **53, 54** connecting conduit **38** and chamber **48**. Pressures at which the water is supplied to chambers **44** and **48** are so selected and related as to insure constant discharge of water from chamber port **50**, and meeting of the fluid discharged from orifice **46** and passing edge **43** with the fluid discharged from port **50** at a location between body **42** and the outer surface of plate **49**, as suggested at **55**. By this arrangement, the kinetic energy of the portion of the jet from orifice **46** that passes the sensed edge **43** is effective through a corresponding portion of the fluid stream emerging from port **50** to develop in chamber **48** a signal pressure the magnitude of which is a function of the lateral position of edge **43**. Stabilization of the jet from orifice **46**, and to some extent at least, stabilization of the stream discharged from port **50** render the functional relationship between signal pressure magnitude and edge position highly dependable and accurate, particularly in a water jet system. Signal pressure is transmitted from chamber **48** to a point of translation or other utilization by a signal pipe connected with the system **48, 54**, for example as shown at **56**.

Fluid is supplied to the supply pipe **38** from a suitable source, for example a water main as at **57** in Fig. 10, with suitable pressure adjustment if necessary. The pressure at which port **50** is supplied with fluid is such as to limit the extent to which the fluid is discharged from the chamber port **50** to less than the distance between port **50** and the location of the more adjacent surface of the body **42**. The pressure at which discharge orifice **46** is supplied is sufficient to insure forceable delivery of the jet to the location at which it meets the flow discharged from port **50**.

From the foregoing, the construction, arrangement and mode of operation of various assemblies embodying the invention and presenting the advantages of its practice will be apparent, and it is to be understood that the breadth and scope of the invention is to be determined solely by the appended claims rather than by the purely exemplary specific disclosures herein made.

I claim:

1. A fluid jet type body-edge sensing device for developing a signal pressure of magnitude corresponding to the lateral position of a sensed edge, said device comprising structure provided with a pair of opposed surfaces spaced apart and on opposite sides of a region of entry of a body, the edge of which is to be sensed; said surfaces respectively being provided with registered apertures, means for continuously supplying fluid to said apertures respectively at different pressures productive of constant fluid discharge from each of them and so related that meeting of said flows occurs within said region of entry, and signal pressure transmission means connected with the supply side of the aperture to which fluid is delivered at lower pressure.

2. A fluid jet type body-edge sensing device according to claim 1, including means for substantially preventing existence of turbulence of fluid delivered to and dis-

charged through the one of said apertures to which fluid is delivered at higher pressure.

3. A fluid jet type body-edge sensing device according to claim 1, wherein said fluid supply means comprises a source of liquid under pressure.

4. A fluid jet type body-edge sensing device according to claim 1, wherein said fluid supply means includes a source of liquid under pressure, said apertures are spaced vertically, said fluid supply means includes means for delivering liquid from said source to the upper of said apertures at a pressure sufficient to insure forceable jet delivery beyond said body, and means for delivering liquid from said source to the lower of said apertures at a pressure limited to prevent fluid dicharged by said lower aperture from reaching said body.

5. A fluid jet type body-edge sensing device for developing a signal pressure of magnitude corresponding to the lateral position of a sensed body edge, said device comprising a pair of structures spaced apart to define between them a throat having an intermediate location for entry of a body the edge of which is to be sensed, a first of said structures having a bore therethrough, a

conduit connected to said first structure for supplying fluid to a flow path extended through said bore and structure overlying said bore and having therein a discharge orifice opening into said throat and of area smaller than the internal cross sectional area of said hose, and means arranged in said bore for substantially preventing existence of turbulence in fluid as it is discharged from said orifice, the second of said structures having therein an internal signal pressure developing chamber having a port opening into said throat in opposed registration with said orifice, a branch conduit connected with the first said conduit and with said chamber and having a pressure reducing valve connected therein, and a signal pressure transmission conduit connected with said chamber.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,919,712

January 5, 1960

Frank J. Markey

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, lines 16 and 17, for "magniture" read -- magnitude --; column 6, line 64, after "body" strike out the comma; same line 64, after "sensed" strike out the semicolon and insert instead a comma; column 8, line 5, for "hose" read -- bore --.

Signed and sealed this 7th day of June 1960.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON

Commissioner of Patents