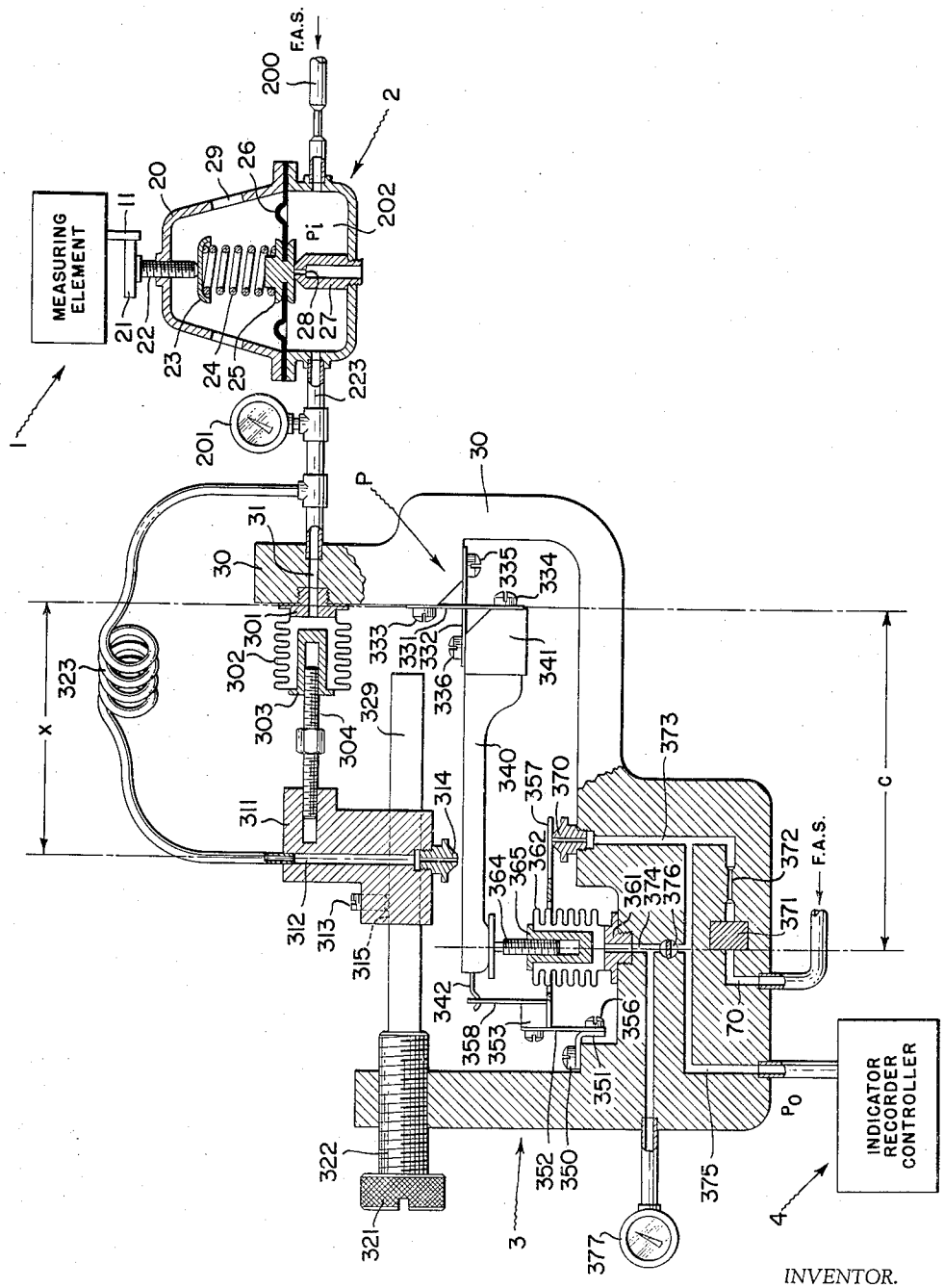
Feb. 21, 1961 R. B. WATROUS 2,972,443

SQUARE COMPUTING DEVICE

Filed Nov. 13, 1957



INVENTOR.
ROBERT B. WATROUS

BY Arthur H. Swanson

ATTORNEY.

United States Patent Office 2,972,443 Patented Feb. 21, 1961

2,972,443

SQUARE COMPUTING DEVICE

Robert B. Watrous, Philadelphia, Pa., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Filed Nov. 13, 1957, Ser. No. 696,176

4 Claims. (Cl. 235—61)

This invention relates to an air-pressure-operated computer.

It is an object of this invention to provide an air-pressure-operated computer in which there is a lever so delicately balanced that it can be moved by the force of one or more jets of air applied thereto.

It is a more specific object of this invention to provide an air-pressure-operated computer which is adapted to compute the square and is therefore useful in connection with flow meters.

A better understanding of the present invention may be had from the following detailed description when read in connection with the accompanying drawings, in which:

In the drawings the single figure is a diagrammatic or schematic showing with parts in vertical cross section.

This invention comprises a measuring element 1 which may be manually operated by hand or automatically operated by any one of a number of various variables. Measuring element 1 has an output 11 which actuates an air-pressure transmitter 2.

Transmitter 2 comprises rigid case 20 having an input element comprised by gear or disc 21, screw-threaded shaft 22 mounted in case 20, and plate 23. Plate 23 bears against the upper end of spring 24, which bears, at its lower end, against disc 25 mounted in the center of flexible diaphragm 26. The edge or rim of diaphragm 26 is secured air-tight in case 20. The center of diaphragm 26 cooperates with a nozzle 27 having an opening 28 therethrough which leads to atmosphere. Air is supplied from a source F.A.S. of filtered air under pressure through pipe 200 to chamber 202 in case 20. From chamber 202 a pipe 223 leads to the computer 3.

Transmitter 2 operates as follows. Any change in the position of measuring element 1 causes plate 23 to vary the pressure which spring 24 exerts against the pressure of the air in chamber 202. This change in the balance of pressures applied to diaphragm 26 causes diaphragm 26 to move relative to nozzle 27 and to thereby vary the pressure in chamber 202 by varying the amount of air which is allowed to escape through orifice 28.

An indicator 201, such as a pressure gauge, is connected to chamber 202 by means of pipe 223.

The computer 3 comprises a base 30 on which the other parts of the computer are mounted. Through base 30 passes an inlet orifice 31 which communicates, at its input, with pipe 223, and, at its output, with a first motor comprised by an input bellows. This input bellows comprises perforated disc 301 mounted on base 30 and mounting the stationary end of a flexible bellows 302. To the free or movable end of bellows 302 is attached a thimble 303 in which is mounted a screw 304 secured at one end to a nozzle support 311. From pipe 223 extends a coil of flexible tubing 323 which connects to a nozzle orifice 312 communicating with a perforated nozzle 314.

The nozzle support 311 has an opening 315 through

it. A nozzle guide 329 passes through opening 315 and is mounted on a screw 322 screw threadedly supported in base 30. A disc 321 is secured to the opposite end of screw 322 from nozzle guide 329.

Nozzle support 311 may be secured in adjusted position along the length of or in rotation about nozzle guide 329 by means of a set screw 313.

Base 30 supports a cross spring pivot having an axis of pivotation (generally indicated by P). Flat strips 331 and 332 comprise this pivot. These strips are secured to flat faces of base 30 and of lever 340 by screws 333, 334, 335 and 336 so that lever 340 is constrained to turn about pivot point P.

Lever 340 is attached at its right end 341 to the cross spring pivot, and, at its left end, carries a hook 342.

Flapper 357 is mounted on base 30 by means of a strip 351 secured to base 30 by screw 350. A screw 356 secures a flexible strip 352 to strip 351. Flapper 357 is secured by means of a screw and block 353 to flexible strip 352. A second flexible strip 358 connects hook 342 on lever 340 to flapper 357.

The right end of flapper 357 cooperates with a stationary output nozzle 370. Feedback air is fed from a source F.A.S. of filtered air under pressure through orifice 70, filter 371, restriction 372 and conduit 373 to stationary nozzle 370. Conduit 373 has two branches. Branch 374 contains a valve 376 or other means for closing it off. Branch 374 communicates with the interior of a second motor comprised by an output bellows comprised of a perforated disc 361 mounted on base 30. To disc 361 is secured the stationary end of bellows 362 which carries, at its upper or free end, a thimble 365 in which is mounted a screw 364 which bears against the left or free end of lever 340. Branch 374 also communicates with pressure gauge 377.

Branch conduit 375 communicates with an indicator, recorder, or controller, generally indicated at 4, and forming the output portion of the device.

The operation of this device, more specifically, the operation of computer 3 is as follows. Any change in the pressure of the air in chamber 202 is fed to input bellows 302 and is also fed through tubing 323 to nozzle 314. The change of pressure in the input bellows 302 moves nozzle 314 along nozzle guide 329. The change of pressure in input conduit 312 varies the force of the jet of air issuing from nozzle 314 and engaging lever 340. The change in the force of the jet of air from nozzle 314 causes lever 340 to turn about its pivot P in one direction or the other. Turning movement of lever 340 moves flapper 357 relative to nozzle 370 and thereby varies the pressure in conduits 373, 374, and 375. Any change in the pressure of the air in output bellows 362 causes the free end thereof to move. This causes the free end of lever 340 to move in a direction opposite to that in which the lever 340 was moved by the jet from nozzle 314. Any change of the pressure of the feedback air in branch conduit 375 causes the indicator, recorder, or controller 4 to be actuated thereby to indicate the change in pressure put out by the device.

The way in which the device operates so that the output is the square of the input is as follows.

P_i represents the pressure in chamber 202 and in input conduit 312 and in the bellows 302.

C equals the distance from pivot P to the point at which the free end 364 of output bellows 362 bears on lever 340.

X equals the distance of the axis of nozzle 314 from pivot P and also equals P_i multiplied by a constant K.

A_n equals the cross-sectional area of the orifice through nozzle 314.

Ab equals the effective area of the output bellows 362.

Po equals the pressure in conduit 375.

The force of the jet of air issuing from nozzle 314 multiplied by the distance X equals the force exerted by the output bellows 362 multiplied by the distance C.

By properly proportioning the distances C and X and the areas An and Ab, the following equation can be made valid.

Po multiplied by C multiplied by Ab equals the force of the jet from nozzle 314 multiplied by X.

Since, the force of the jet equals Pi multiplied by An; and X equals Pi multiplied by a constant K.

Po multiplied by C multiplied by Ab equals Pi multiplied by K multiplied by Pi multiplied by An.

Since C, An, Ab, and K are constants.

Po equals Pi (squared), when the constants have been proportioned such that Ab multiplied by C equals An multiplied by K.

Another way in which the device of this invention may be operated is as follows. Nozzle 314 is located at a fixed distance X from pivot P by locking screw 313 against nozzle guide 329. This causes the pressure in input bellows 302 to be unable to move nozzle 314 and therefore the distance X cannot be varied and therefore the effective lever arm of lever 340 in a counterclockwise direction remains constant.

The following equation represents this mode of operation.

Pi multiplied by An multiplied by X equals Po multiplied by C multiplied by Ab.

Since An, Ab and C are constants, X can be selected by locking screw 313 at a suitable distance from pivot P to adjust the ratio between Pi and Po to a desired value.

Having now described my invention what I claim as new and desire to secure by Letters Patent is as follows:

1. An air-pressure-operated computer, including, a lever mounted on a pivot and having a free end, a nozzle mounted adjacent said lever so as to apply a jet of air thereto with sufficient force to turn about its pivot, a first motor connected to said nozzle so as to move it toward or away from the pivot of said lever in response to the pressure of the air controlled by said nozzle, a valve connected to said lever so as to be opened or closed thereby and to thereby vary the flow of air through said valve and, consequently, the pressure of said air controlled by said valve, a second motor actuated by the pressure of the air controlled by said valve to move said lever in a direction opposite to that in which said lever is moved by said jet of air, and an output element connected to and actuated by the pressure of the air controlled by said valve.

2. An air-pressure-operated computer, including, a lever, a base, a cross spring pivot mounting said lever on said base, a nozzle guide mounted on said base and extending substantially parallel to said lever, a nozzle mounted on said nozzle guide for movement therealong, a first air-pressure-operated motor mounted on said base and connected to said nozzle so as to move it, a first supply of air connected to said first motor and to said nozzle so as to actuate said first motor and to supply a jet of fluid through said first nozzle against said lever with sufficient force to turn said lever about its pivot, a flapper-nozzle valve, a flexible connection between the free end of said lever and said flapper to move said flapper relative to its cooperating nozzle, a second supply of air, said flapper-nozzle valve being adapted to vary the pressure of said second supply of air, a second air-pressure-operated motor connected to said second supply of air and actuated thereby, said second air-pressure-operated motor operating said lever in a direction opposite to that in which said lever is operated by said jet of fluid, and an output connection to said second supply of fluid adapted to be connected to an output indicator, recorder, or controller.

3. An air-pressure-operated computer, including, a lever comprising an elongated beam mounted for substantially frictionless oscillation about an axis of pivotation and having a free end, a nozzle mounted adjacent said lever and spaced from its axis of pivotation so as to apply a jet of air to said lever with sufficient force and in such a direction as to cause said lever to oscillate about its axis of pivotation, means for varying the pressure of the air supplied to said nozzle and for varying the force which the jet applies to said lever in accordance with a variable to be measured, a feedback air supply, means operated by the movements of the free end of said lever and operable to vary the flow of feedback air through said last-mentioned means and, consequently, to vary the pressure of said feedback air, means operated by the pressure of said feedback air and operative upon the free end of said lever to oscillate said lever about its axis of pivotation in a direction opposite to that in which said lever is oscillated by said jet of air, and an output element connected to and actuated by the pressure of said feedback air.

4. An air-pressure-operated computer, including, a lever comprising an elongated beam mounted for substantially frictionless oscillation about an axis of pivotation and having a free end, a nozzle mounted adjacent said lever and spaced from its axis of pivotation so as to apply a jet of air to said lever with sufficient force and in such a direction as to cause said lever to oscillate about its axis of pivotation, means for varying the pressure of the air supplied to said nozzle and for varying the force which the jet applies to said lever in accordance with a variable to be measured, means connected to said nozzle and operable to move said nozzle along said lever toward or away from its axis of pivotation in response to the pressure of the air supply of said nozzle, a feedback air supply, means operated by the movements of the free end of said lever and operable to vary the flow of feedback air through said last-mentioned means and, consequently, to vary the pressure of said feedback air, means operated by the pressure of said feedback air and operative upon the free end of said lever to oscillate said lever about its axis of pivotation in a direction opposite to that in which said lever is oscillated by said jet of air supplied to said nozzle, and an output element connected to and actuated by the pressure of said feedback air.

References Cited in the file of this patent

UNITED STATES PATENTS

2,643,055	Sorteberg	June 23, 1953
2,659,531	Thoresen	Nov. 17, 1953
2,736,199	Ibbott	Feb. 28, 1956