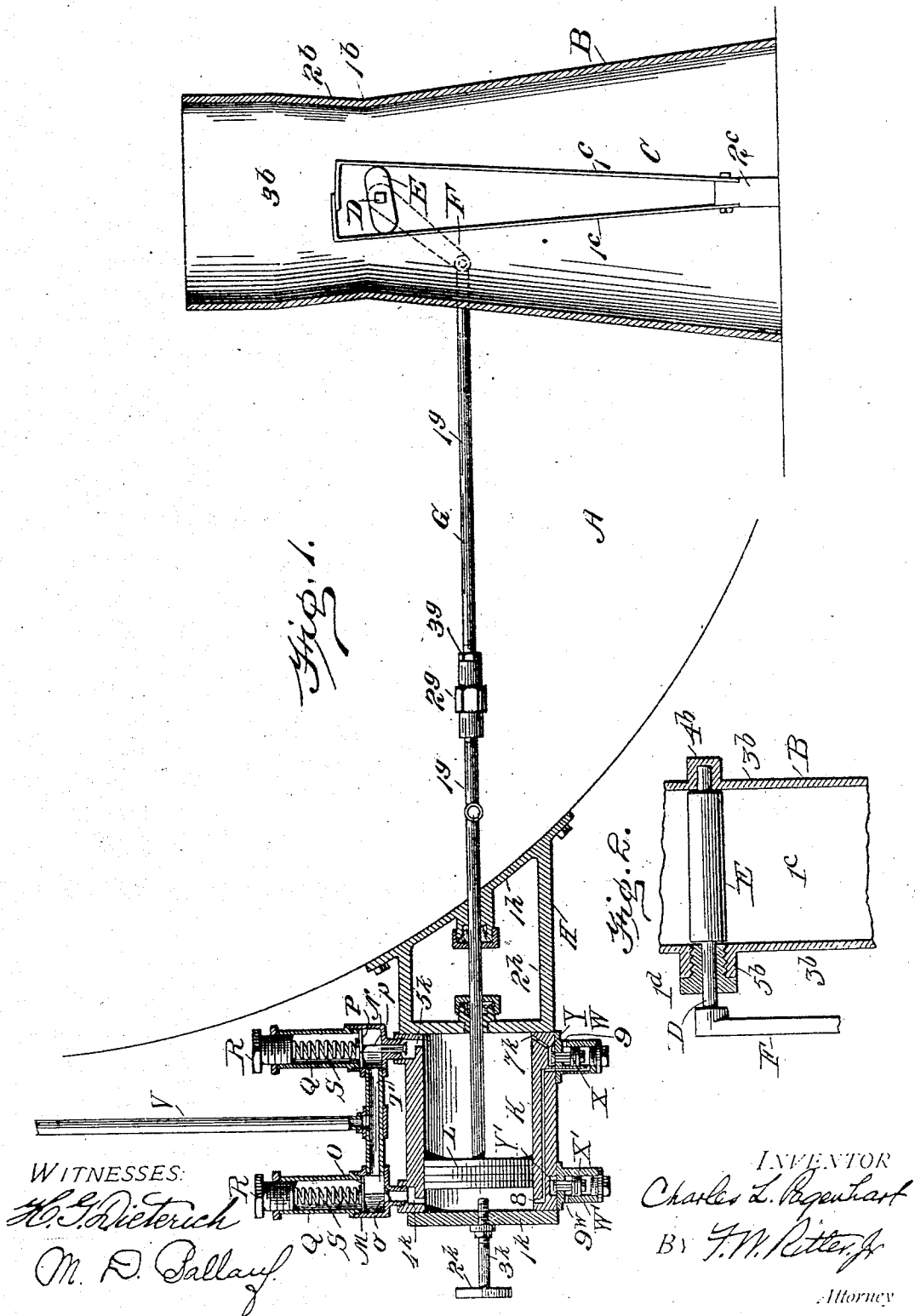


No. 794,881.

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PATENTED JULY 18, 1905.

C. L. PAGENHART.
VARIABLE EXHAUST MECHANISM.
APPLICATION FILED OCT. 12, 1904.



UNITED STATES PATENT OFFICE.

CHARLES L. PAGENHART, OF TENNILLE, GEORGIA, ASSIGNOR OF TWO-THIRDS TO DAVID R. THOMAS AND JULIUS BASHINSKI, JR., OF TENNILLE, GEORGIA.

VARIABLE-EXHAUST MECHANISM.

SPECIFICATION forming part of Letters Patent No. 794,881, dated July 18, 1905.

Application filed October 12, 1904. Serial No. 228,213.

To all whom it may concern:

Be it known that I, CHARLES L. PAGENHART, a citizen of the United States, residing at Tennille, in the county of Washington and State of Georgia, have invented certain new and useful Improvements in Variable-Exhaust-Mechanism for Application to Steam-Engines Wherever Such a Device is Desirable to be Employed; and I hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, in which—

Figure 1 is a vertical central section of a mechanism embodying my invention, shown in connection with the exhaust-column and exhaust-column bridge of a locomotive to control the exhaust thereof. Fig. 2 is an enlarged detail section of a portion of the exhaust-column, showing the column-bridge-adjusting cam mounted therein, and a portion of one section of the adjustable column-bridge.

Like symbols refer to like parts wherever they occur.

My invention relates to that class of devices especially designed to govern or control the exhausts of steam-engines, but generally applicable for exhaust purposes under similar conditions, and has for its objects to produce a mechanism which shall automatically increase or decrease the draft accordingly as the steam-pressure may fall below or rise above the normal and to generally reduce the back pressure, as well as prevent the back pressure of one cylinder upon an opposite cylinder, thereby saving a large percentage of the fuel ordinarily necessary, while at the same time producing a more efficient engine and locomotive of increased and more uniform speed and power. Hitherto in the construction of variable-exhaust mechanism designed to accomplish these several before-noted objects cones or other devices adapted to vary the area of the opening in the exhaust-nozzle have been commonly employed, or flap or other valves have been used; but a construction such as the former type impairs the efficient working of the engine by reason of the back pressure created by the obstruction thus placed cen-

trally of the exhaust-nozzle, and devices of the latter type generally produce cross-firing of the exhaust in the stack and soon become inefficient by reason of the constant vibration and oscillation to which they are subjected when in service.

To accomplish the before-noted objects and to overcome the objections pointed out, I combine with the exhaust-column of an engine an exhaust-column bridge separating the cylinder exhaust-ports, said bridge having upwardly-diverging sides and having its upper extremity adjacent to the choke of the exhaust-column preferably slightly above the same.

A second feature of my invention resides in so arranging and constructing the exhaust-column bridge that the exhaust area of the exhaust-column may be varied by a change in the form of the said exhaust-column bridge.

A third feature of my invention resides in the means for automatically adjusting and controlling the exhaust-column bridge, said means comprising a plurality of differently-graduated valves interposed between a common source of pressure and a cylinder the movement of whose piston actuates the adjustable exhaust-column bridge by any suitable connections.

A fourth feature of my invention resides in an automatic exhaust-valve mechanism for the cylinder whose piston actuates the exhaust-column bridge.

There are other minor features of invention residing in particular combinations and elemental constructions, all as will hereinafter more fully appear and be particularly pointed out in the claims.

I will now proceed to describe my invention more fully, so that others skilled in the art to which it appertains may apply the same.

While I have illustrated my devices as applied to a locomotive, yet it will be understood that my invention as pointed out in the claims is of broader scope and may be applied to any engine wherein a forced draft is desirable, and similarly the automatic means

for controlling the form and size of the adjustable column-bridge and the means for automatically controlling the exhaust of the cylinder which actuates the column-bridge are of more general application in the arts.

In the drawings, A is the smoke-box of a locomotive, having therein an exhaust-column B, the lower end of which is secured to the cylinder-saddle (not shown) connected to the cylinders (not shown) through usual and well-known exhaust-ports or in other suitable manner. The exhaust-column B is preferably gradually contracted in area to the choke 1^b thereof and from thence is preferably increased in area for at least a part 2^b of its remaining length, the converging walls of the lower portion of said exhaust-column B, if prolonged, preferably meeting at a point in the longitudinal axis of the stack (not shown) and adjacent to the lower end of the latter; but, if desired, any other suitable form of exhaust-column may be employed.

Within the exhaust-column B and interposed between the exhaust-ports connected to the cylinders in such manner as to divide said exhaust-column into two independent compartments is the exhaust-column bridge C, which is preferably constructed with upwardly-diverging sides and which terminates at or adjacent to the choke 1^b of the exhaust-column B, the outwardly flaring or diverging sides directing the exhaust centrally upward through the column and counteracting the tendency of the exhaust-steam to cross to the opposite side of the column and to create back pressure on the opposite cylinder, thus preventing any decrease of the effective pressure upon such opposite cylinder. By this means also the exhaust-steam from one cylinder does not cross the path of the exhaust-steam from the other cylinder, and the swirling of the steam, which is so detrimental to a perfect draft and a free exhaust, is obviated. The exhaust-column bridge C, which, as will herein appear, is a means for regulating the draft in the stack, is preferably constructed of a plurality of resilient sections 1^c 1^c, which are bolted or otherwise secured to the column-bridge base 2^c, the latter being rigidly fastened to the base of the exhaust-column intermediate the cylinder exhaust-ports leading thereinto, said resilient sections 1^c 1^c having their upper ends bent inwardly to overlap and closely engage each other, thus forming a closure for the top of said adjustable column-bridge and permitting a relative movement toward and from each other of the two sections. If desired, the edges of the resilient members 1^c 1^c may be provided with spring-pressed packing-strips which engage the flattened walls 3^b 3^b of the exhaust-column B, thus preventing any possible leakage from one exhaust-compartment to the other exhaust-compartment of the said exhaust-column.

While I prefer to form the sections 1^c 1^c of the adjustable exhaust-column bridge C of resilient material such that the said sections will always have a tendency to approach each other, yet it is obvious that this function may be accomplished by a spring interposed between the sections and bearing upon each. It is apparent also that the sections 1^c 1^c of the adjustable exhaust-column bridge may be constructed of a single piece of metal formed into the proper shape.

The cam-shaft D, to which is secured the cam E, is journaled in the exhaust-column B near the choke 1^b thereof, one of its ends engaging the corresponding socket 4^b of the said column B, (see Fig 2,) the other end passing through a thimble 1^d, which engages the interiorly-threaded nipple 5^b of the exhaust-column; but, if desired, other means may be employed for this purpose.

The cam or double eccentric E, which is interposed between the resilient sections 1^c 1^c of the exhaust-column bridge C and is a means both for adjusting the said sections 1^c 1^c and retaining them in an adjusted position, is preferably formed with a square aperture running axially therethrough for engaging a correspondingly-formed portion of the cam-shaft D, said cam being thereby fixed to its shaft in respect of any relative turning movement; but other well-known means—as, for example, a key or spline—may be employed to secure the cam to its shaft.

Rigidly attached in any suitable manner to that end of the cam-shaft D which passes through the exhaust-column B is the lever or crank F, said crank having its opposite end flexibly secured to the reach-rod G by a knuckle-joint or other connection of like character.

For the purpose of readily adapting the device to different locomotives, as well as to relatively adjust the parts and to readily assemble the same, I prefer to form the reach-rod G of a plurality of sections 1^e 1^e, connected by a turnbuckle 2^e, the latter being engaged by the jam-nut 3^e, which restrains any movement of the latter, and thus affords a means for securing the sections of the reach-rod in a fixed relation; but other means whereby the reach-rod may be rendered extensible in character may be employed, or the reach-rod may be constructed as an integral member.

Bolted or otherwise secured upon the exterior of the smoke-box is a bracket H, preferably comprising a base-plate 1^h, conforming to that part of the locomotive to which it is applied, and an open yoke 2^h, the said base-plate and yoke being each provided with a stuffing-box of any usual or suitable construction either made integral therewith or detachable therefrom.

While I prefer to locate the bracket H, which forms the support for the cylinder controlling the exhaust-column bridge C, con-

tiguous to the smoke-box, yet said bracket and the mechanism carried thereby may obviously be located in any other suitable position upon the engine or locomotive.

5 Secured to the bracket H by bolts passing through an angular flange or in other suitable manner is the cylinder K, the head 1^k whereof is provided with a hand-wheel 2^k and attached threaded rod 3^k, having threaded engagement
10 with the said cylinder-head 1^k, by which means the length of stroke of the piston or other movable member L within the cylinder K is limited and by which primarily the minimum area of the exhaust-opening of the exhaust-
15 column is regulated through the cam or double eccentric E, which controls the relative position of the resilient members 1^c 1^c, constituting the adjustable exhaust-column bridge C; but, if desired, other means for regulating
20 the minimum area of the exhaust and the corresponding maximum separation of the adjustable members of the said column-bridge may be employed.

Within the cylinder K is a piston L of any
25 well-known or suitable construction, the piston-rod whereof is flexibly connected to the reach-rod G, preferably by a knuckle-joint, said piston-rod passing through and being guided by the stuffing-boxes of the bracket H.

30 The cylinder K is provided with ports 4^k 5^k for the admission of steam to the cylinder on opposite sides of the piston and is also preferably provided with corresponding leakage-grooves or exhaust-ports 6^k 7^k of comparatively
35 small area for the escape of steam and of water of condensation; but, if desired, automatically-controlled exhaust-valves may be substituted for such leakage grooves or ports, or bib-cocks or other valves may be employed
40 in addition to such leakage ports or valves.

When automatic exhaust-valves are desired to control the leakage-grooves or exhaust-ports 6^k 7^k of main cylinder K, I preferably employ the means therefor devised by me and
45 shown in the drawings—that is to say, I secure to the cylinder K adjacent or in line with the exhaust-ports 6^k 7^k valve-cases or supplemental cylinders W W', each of which is connected with the opposite end of main cylinder
50 K by a live-steam port or passage 8 (or 8^w) and provided with an exhaust-port 9, (or 9^w), and within each of said valve-cases I provide a piston X (or X') or diaphragm, which is connected with the adjacent valve Y, (or Y'),
55 which controls the exhaust-port 6^k, (or 7^k), so that when there is no pressure or the pressure is uniform on both heads of piston L of main cylinder K said valve Y (or Y') remains seated; but as soon as the pressure becomes
60 greater upon one head of the piston than on the other the said pressure will act through the port 8 (or 8^w) upon piston X (or X') to open valve Y, (or Y'). The unseating of valve Y at once puts exhaust-port 6^k in communica-

tion with exhaust-port 8, while the unseating 6^k of valve Y' puts exhaust-port 7^k in communication with exhaust-port 9^w. It is evident that this automatic exhaust mechanism is applicable to the control of the leakage or exhaust ports of fluid-pressure cylinders in general.

Mounted upon the cylinder K in any suitable manner, as by being threaded thereinto, are the diaphragm-bodies M and N, the same having valved passages therein communicating with the ports 4^k 5^k, respectively, and also having apertures to receive a pipe or other means for transmitting pressure to the diaphragms O P, as will hereinafter appear.

Mounted within the respective diaphragm-bodies M and N, and preferably secured therein by means of the spring-cases Q Q, which are or may be threaded to engage corresponding threads of said diaphragm-bodies are the diaphragms O and P, the latter being formed
85 of any suitable flexible material, preferably copper or brass.

Secured to the diaphragm O is the high-pressure valve o, which is adapted to be lifted from its seat within the diaphragm-body M to
90 admit steam or other fluid pressure to cylinder K through the port 4^k when the steam-pressure in the boiler rises above the limit at which said high-pressure valve o is set to open, the low-pressure valve p, located within the
95 diaphragm-body N, being similarly secured to its diaphragm P, but being adapted to open to admit pressure to the cylinder K through the port 5^k when the steam-pressure in the boiler falls below the pressure at which said
100 last-named valve is set to open.

In lieu of the diaphragms I may substitute pistons working in the spring-cases Q Q; but a construction employing such diaphragms is preferable, as the opening of the attached
105 valves is thus limited in a very simple manner and a tight steam-joint is readily secured.

Preferably housed within spring-cases Q Q are the springs S S, each of said springs being interposed between one of the diaphragms
110 O P and one of the adjusting-nuts R R, by which the pressure of such springs upon the diaphragms and attached valves may be graduated. It will be noted that the springs S S are the preferred means for maintaining a constant pressure of predetermined amount upon the respective valves; but other means for this purpose may be employed, or under suitable conditions of operation the diaphragms themselves may be made of the desired difference in stiffness.

The interior chambers of the diaphragm-bodies M and N, which open into the cylinder K, are connected to a common source of pressure through the pipe T, which connects the
125 diaphragm-bodies and the pipe V, which is supplied with steam at boiler-pressure; but other means may be adopted for this purpose,

if desired—as, for example, each diaphragm-body may be independently connected to the boiler-pressure.

The construction being substantially such as hereinbefore pointed out, the device will operate as follows: The mechanism having been assembled and placed in position on the locomotive, the turnbuckle 2^s having been manipulated to make the reach-rod G of proper length, the desired minimum exhaust area of the exhaust-column at the choke having been fixed by properly adjusting the screw-rod 3^k by means of the hand-wheel 2^k, and the adjusting-nuts R R having been operated to produce pressure upon the respective valves corresponding to the pressures at which it is desired they shall open to admit steam to the cylinder K, the live steam from the boiler will pass through the pipes V and T to the interior chambers of the diaphragm-bodies M and N. If at this time the steam-pressure is within the limits of variation it is desired to allow, such variation being represented by the difference between the spring-pressure upon the high-pressure valve *o*, which is designed to open when the steam-pressure exceeds the desired upper limit, and the spring-pressure upon the low-pressure valve *p*, which is designed to open when the steam-pressure falls below the desired lower limit, then both high-pressure valve *o* and low-pressure valve *p* will remain closed, since the pressure of steam is insufficient to overcome either spring, and the adjustable exhaust-column bridge will be unaffected and will maintain the exhaust area at the choke of the exhaust-column which it has been designed or adjusted to have under normal conditions. If now the steam-pressure should rise above the upper limit at which the high-pressure valve *o* is set, such excessive pressure acting upon the diaphragms O and P through the pressure-pipes V and T will overcome the spring-pressure upon the diaphragm O, causing the latter and the attached valve *o* to rise, thus admitting steam to the cylinder K through the port 4^k, and the pressure entering the main cylinder K through the port 4^k will pass through that end of the cylinder and through port 8 to valve-case or supplemental cylinder W and unseat exhaust-valve Y, thus opening the leakage-port 6^k to exhaust-port 9. During this time the steam-pressure upon the diaphragm P is greater than the spring-pressure thereon, and the low-pressure valve *p* consequently remains closed. It thus results that the piston L is moved in a direction to slightly rotate the cam E and permit the resilient sections 1° 1° of the exhaust-column bridge to more closely approach each other, thereby increasing the exhaust area at the choke of the exhaust-column, and thus permitting a freer exhaust, while at the same time decreasing the draft in the stack. When the pressure of steam in the boiler has dropped by reason of the de-

creased draft until it is below the pressure at which the high-pressure valve *o* is set, such valve *o* is closed through the spring acting thereon. If now the steam-pressure in the boiler should fall below the limit at which the low-pressure valve *p* is designed to open, such steam-pressure acting through the pipes V and T will be communicated to the diaphragms O and P and will be insufficient to overcome the spring-pressure maintaining the high-pressure valve closed, but will permit the spring-pressure upon the low-pressure valve *p* to open said last-named valve, as shown in Fig. 1, to admit steam to the cylinder K through the port 5^k, which steam will also pass through port or passage 8^w to valve-case or supplemental cylinder W' and unseat the exhaust-valve Y', thus opening the leakage-port 6^k to the exhaust-port 9^w. At the same time the piston L is moved to cause a slight rotation of the cam E, which results in a spreading or separation of the sections 1° 1° of the exhaust-column bridge, thus decreasing the area of the exhaust at the choke of the exhaust-column by changing the form of said column-bridge, and thereby increasing the draft. When the steam-pressure in the boiler has risen above the pressure at which the low-pressure valve is set, such pressure thereupon closes said valve.

While I have illustrated and described a particular mechanism for automatically actuating my adjustable exhaust-column bridge, yet it is evident that other forms of apparatus may be employed for this purpose or that such exhaust-column bridge may be operated manually, and while I have shown and described a preferred means for automatically admitting steam to the cylinder controlling the operation of such adjustable exhaust-column bridge other means for this purpose may be employed—as, for example, a slide-valve or a triple valve.

My invention is susceptible of many modifications and many changes in construction and form of parts without departing from the spirit thereof.

Having thus described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge within said exhaust-column, substantially as and for the purposes specified.

2. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge within said exhaust-column, and means for adjusting said exhaust-column bridge, substantially as and for the purposes specified.

3. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge within said exhaust-column, and pressure-controlled

means for automatically adjusting said exhaust-column bridge, substantially as and for the purposes specified.

4. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge having upwardly-diverging walls, substantially as and for the purposes specified.

5. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge comprising a plurality of relatively movable sections, substantially as and for the purposes specified.

6. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge comprising a plurality of resilient sections, substantially as and for the purposes specified.

7. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge adapted to vary the exhaust area of said exhaust-column by a variation in form of the said exhaust-column bridge, substantially as and for the purposes specified.

8. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge within said exhaust-column, said bridge comprising a plurality of sections normally tending to approach each other, substantially as and for the purposes specified.

9. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge comprising a plurality of relatively movable sections, and means for moving said sections relatively, substantially as and for the purposes specified.

10. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge comprising a plurality of relatively movable sections, and a cam for moving said sections relatively, substantially as and for the purposes specified.

11. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge comprising a plurality of relatively movable resilient sections, and means for moving said sections relatively, substantially as and for the purposes specified.

12. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge comprising a plurality of relatively movable resilient sections, and a cam for moving said sections relatively, substantially as and for the purposes specified.

13. In a variable-exhaust mechanism, the combination with an exhaust-column having

a choke, of means within said exhaust-column for varying the exhaust area of said exhaust column at the choke, substantially as and for the purposes specified.

14. In an exhaust mechanism, the combination with an exhaust-column having upwardly-converging walls, of an exhaust-column bridge within said exhaust-column, said bridge having upwardly-diverging walls, substantially as and for the purposes specified.

15. In an exhaust mechanism, the combination with an exhaust-column having upwardly-converging walls, a choke and diverging walls above said choke, of an exhaust-column bridge having upwardly-diverging walls terminating adjacent to said choke, substantially as and for the purposes specified.

16. In an exhaust mechanism, the combination with an exhaust-column having upwardly-converging walls, a choke and diverging walls above said choke, of an exhaust-column bridge having upwardly-diverging walls terminating adjacent to said choke, substantially as and for the purposes specified.

17. In a variable-exhaust mechanism, the combination with an exhaust-column having upwardly-converging walls, a choke and diverging walls above said choke, of an adjustable exhaust-column bridge comprising a plurality of resilient sections terminating adjacent to said choke, substantially as and for the purposes specified.

18. In a variable-exhaust mechanism, the combination with an exhaust-column having upwardly-converging walls, a choke and diverging walls above said choke, of an adjustable exhaust-column bridge comprising a plurality of resilient sections terminating adjacent to said choke, and a cam adapted to actuate said resilient sections, substantially as and for the purposes specified.

19. In a variable-exhaust mechanism, the combination with an exhaust-column having upwardly-converging walls, a choke and diverging walls above said choke, of an adjustable exhaust-column bridge comprising a plurality of relatively movable sections terminating adjacent to said choke, and means for moving said sections relatively, substantially as and for the purposes specified.

20. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge comprising a plurality of relatively movable sections, and means for automatically moving said sections relatively, substantially as and for the purposes specified.

21. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge comprising a plurality of relatively movable resilient sections, and means for automatically moving said sections relatively, substantially as and for the purposes specified.

22. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge adapted to vary the exhaust area of said exhaust-column, and means or automatically actuating said exhaust-column bridge to vary said exhaust area, substantially as and for the purposes specified.

23. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge within said exhaust-column, said bridge adapted to vary the exhaust area of said exhaust-column, a cylinder, a piston within said cylinder, means for automatically actuating said piston, and devices interposed between said piston and said exhaust-column bridge for actuating the latter, substantially as and for the purposes specified.

24. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge within said exhaust-column, a cylinder, a piston within said cylinder, pressure-controlled means for actuating said piston, means for limiting the length of stroke of said piston, and devices interposed between said piston and said exhaust-column bridge for actuating the latter, substantially as and for the purposes specified.

25. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge within said exhaust-column, a cylinder, a piston within said cylinder, a high-pressure valve controlling a cylinder-port, a low-pressure valve controlling a cylinder-port, a diaphragm acting upon said high-pressure valve, a diaphragm acting upon said low-pressure valve, and means interposed between said piston and said exhaust-column bridge for actuating the latter, substantially as and for the purposes specified.

26. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge within said exhaust-column, a cylinder, a piston within said cylinder, a high-pressure valve controlling a cylinder-port, a low-pressure valve controlling a cylinder-port, and means interposed between said piston and said exhaust-column bridge for actuating the latter, substantially as and for the purposes specified.

27. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge within said exhaust-column, a cylinder, a piston within said cylinder, a high-pressure valve controlling a cylinder-port, a low-pressure valve controlling a cylinder-port, springs acting upon said valves, and means interposed between said piston and said exhaust-column bridge for actuating the latter, substantially as and for the purposes specified.

28. In a variable-exhaust mechanism, the combination with an exhaust-column, of an

adjustable exhaust-column bridge comprising a plurality of relatively movable sections within said exhaust-column, a cam interposed between said sections and adapted to actuate the same, a crank adapted to actuate said cam, a cylinder, a piston within said cylinder, means for automatically actuating said piston, and a reach-rod flexibly connected to said crank and said piston, substantially as and for the purposes specified.

29. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge comprising a plurality of relatively movable sections within said exhaust-column, a cam interposed between said sections and adapted to actuate the same, a cylinder, a piston within said cylinder, means for limiting the stroke of said piston, means for automatically actuating said piston, and devices interposed between said piston and said cam for actuating the latter, substantially as and for the purposes specified.

30. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge comprising a plurality of relatively movable sections within said exhaust-column, a cam interposed between said sections and adapted to actuate the same, a crank adapted to actuate said cam, a cylinder, a movable member within said cylinder, a high-pressure valve controlling a cylinder-port, a low-pressure valve controlling a cylinder-port, diaphragms for said valves, springs acting upon said diaphragms, means for graduating the pressure of said springs upon their respective diaphragms, and means interposed between said movable member and said cam for actuating the latter, substantially as and for the purposes specified.

31. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge comprising a plurality of relatively movable sections within said exhaust-column, a cylinder, a piston within said cylinder, a high-pressure valve controlling a cylinder-port, a low-pressure valve controlling a cylinder-port, diaphragms for said valves, means for transmitting pressure to said diaphragms, and means interposed between said piston and said exhaust-column bridge for actuating the latter, substantially as and for the purposes specified.

32. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge within said exhaust-column, a cylinder, a piston within said cylinder, a high-pressure valve controlling a cylinder-port, a low-pressure valve controlling a cylinder-port, diaphragms for said valves, springs acting upon said diaphragms, means for graduating the pressure of said springs upon their respective diaphragms, means for transmitting pressure to said diaphragms, and devices interposed between said

piston and said exhaust-column bridge for actuating the latter, substantially as and for the purposes specified.

33. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge comprising a plurality of resilient sections within said exhaust-column, a cylinder, a piston within said cylinder, means for automatically actuating said piston, and means interposed between said piston and said exhaust-column bridge for actuating the latter, substantially as and for the purposes specified.

34. In a variable-exhaust mechanism, the combination with a draft-regulator, of a high and low pressure cylinder, and independent high and low pressure valves operative to control the admission of pressure to the said cylinder, substantially as and for the purposes specified.

35. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge, a high and low pressure cylinder, independent high and low pressure valves operative to control the admission of pressure to the said cylinder, and means operative by the admission of pressure to the cylinder for actuating said adjustable bridge, substantially as and for the purposes specified.

36. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge, a source of pressure, and means operated by variations in said pressure for actuating said exhaust-column bridge, substantially as and for the purposes specified.

37. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge, a cylinder, a source of pressure connected to said cylinder, and means actuated by variations in said pressure for operating said exhaust-column bridge, substantially as and for the purposes specified.

38. In a variable-exhaust mechanism, the

combination with an exhaust-column, of an adjustable exhaust-column bridge, a cylinder, a movable member within said cylinder, pressure-controlled means for actuating said movable member, and devices interposed between said movable member and said exhaust-column bridge for actuating the latter, substantially as and for the purposes specified.

39. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge having a closure for the top thereof, substantially as and for the purposes specified.

40. In a variable-exhaust mechanism, the combination with an exhaust-column, of an adjustable exhaust-column bridge having a closure for the top thereof, and means for adjusting said exhaust-column bridge, substantially as and for the purposes specified.

41. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge comprising a plurality of relatively movable sections having their upper ends engaging each other to form a closure for the top of said exhaust-column bridge, substantially as and for the purposes specified.

42. In a variable-exhaust mechanism, the combination with an exhaust-column, of an exhaust-column bridge comprising a plurality of resilient sections having their upper ends bent inwardly to form a closure for the top of said exhaust-column bridge, substantially as and for the purposes specified.

43. An exhaust-column bridge comprising a plurality of resilient sections provided with a closed top.

In testimony whereof I affix my signature, in presence of two witnesses, this 10th day of October, 1904.

CHARLES L. PAGENHART.

Witnesses:

OTIS ELLISON,
H. C. CARROLL.