United States Patent

Terada

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[54] **IMPACT AIR DRIVEN TOOL**

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Feb. 19, 1970 Japan 45/14405

[52] **U.S. Cl.**..................................**173/137,** 173/138
[51] **Int. Cl.**..............................**E21b 1/00,** B25d 9/00
[58] **Field of Search**.......................173/135, 137, 138

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Primary Examiner—David H. Brown
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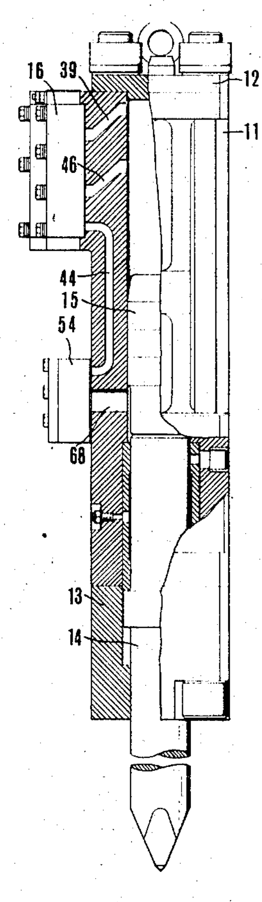
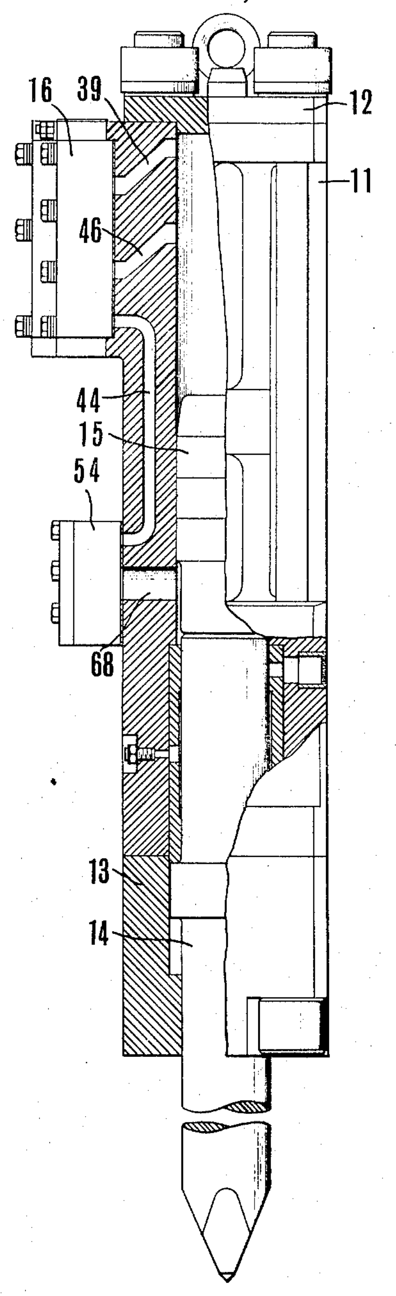
[57] **ABSTRACT**

An impact air driven tool. A cylinder has a piston slidable therein for striking a chisel, the chisel being operatively supported by a chisel holder secured to one end of said cylinder. A valve member is mounted within a valve casing and is reciprocated within said casing by piston operating air supplied into an upper cylinder cavity above the uppermost end surface of the piston and a lower cylinder cavity beneath the lowermost end surface of the piston. A limiting valve is provided and is operated by a variation of the amount of air within said cylinder for change-over of supply of said piston operating air to said valve member. A throttle valve is disposed in an intermediate portion of a passage through which compressed air for shifting the valve member from the advanced position to the original position is supplied from the limiting valve to the valve member. The throttle valve controls the flow of air to the valve member and thereby adjusts the duration of the piston resting phase during which the valve member is shifted.

2 Claims, 9 Drawing Figures



FIG,1



HIROMU TERADA,
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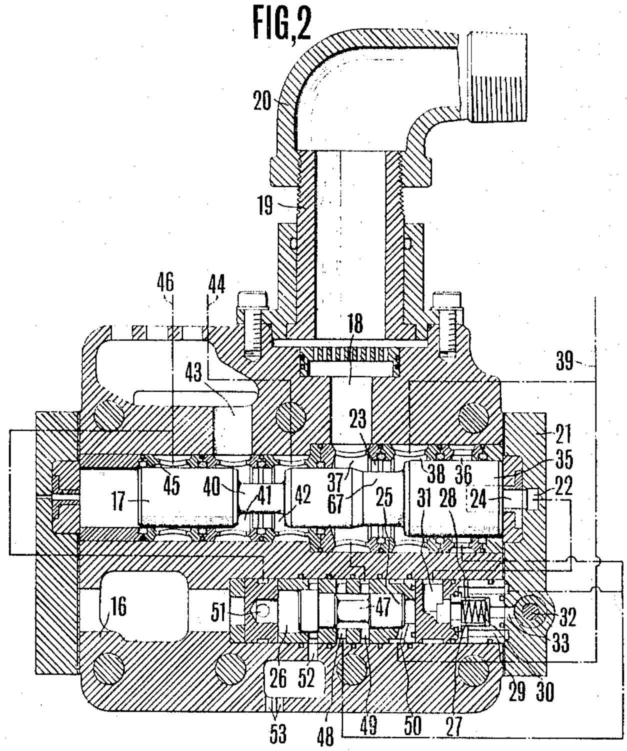
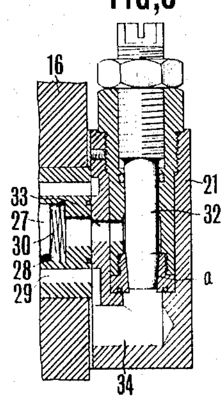
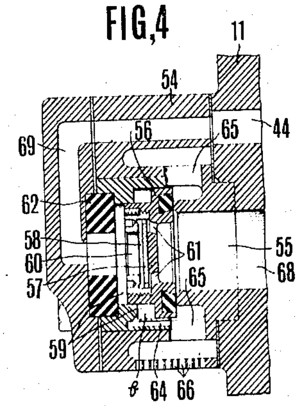
FIG,2



FIG,3



FIG,4



HIROMU TERADA,
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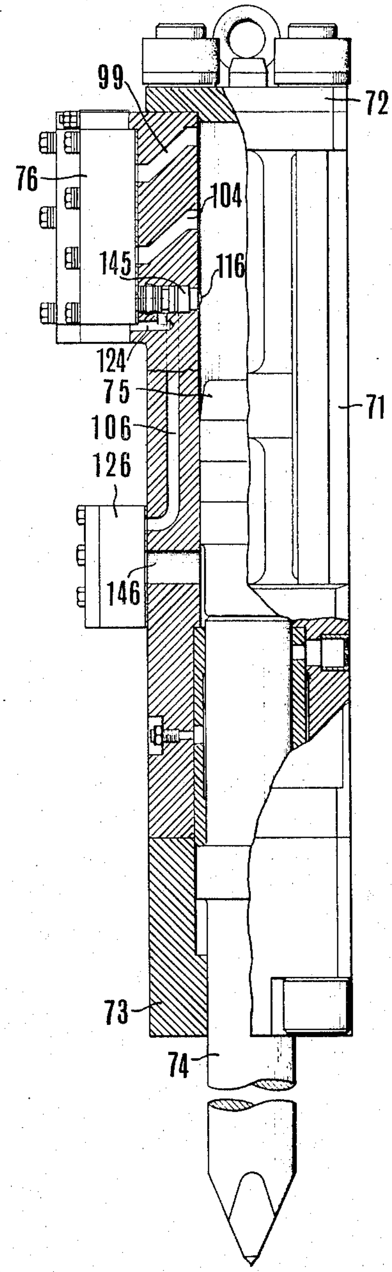
FIG,5



HIROMU TERADA,
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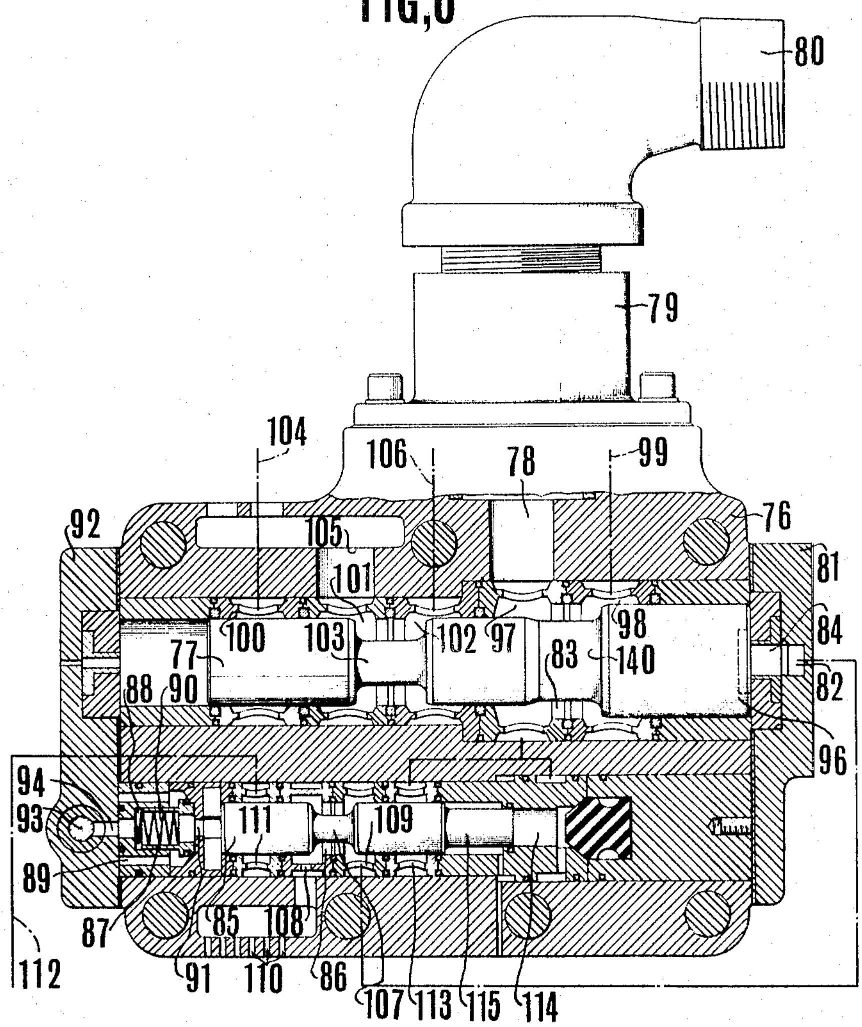
FIG,6



HIROMU TERADA,
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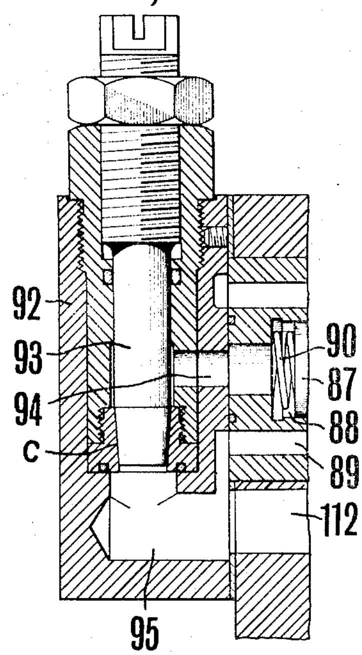
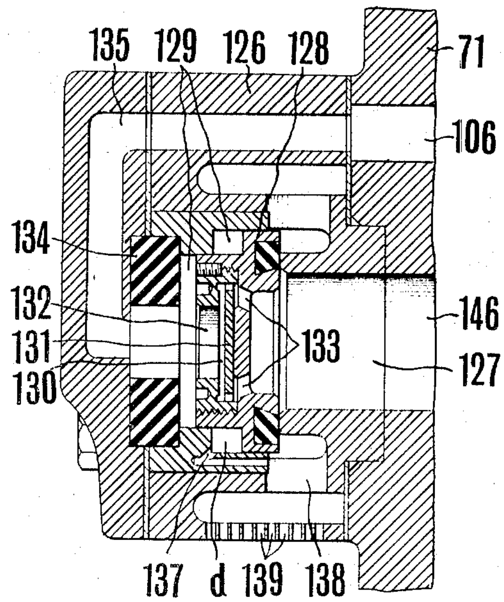
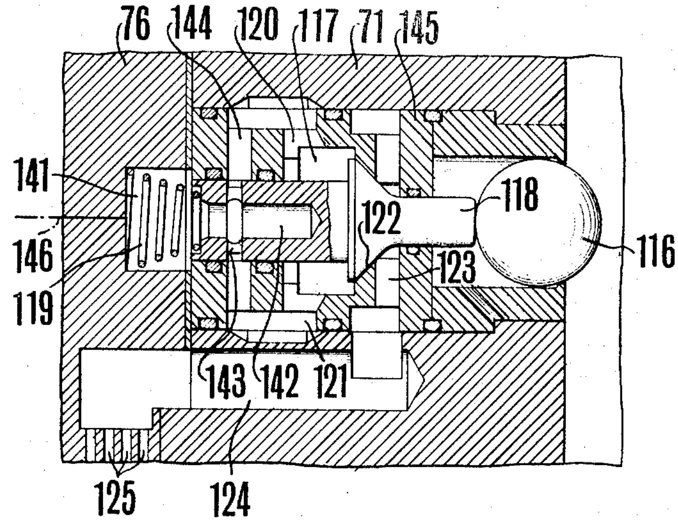
FIG,7



FIG,8



FIG,9



HIROMU TERADA,
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IMPACT AIR DRIVEN TOOL

The present invention relates to an impact air driven tool utilizing compressed air for producing destructive forces.

The present invention has in its object to provide an impact air driven tool with which, as compared with one exemplary type of conventional impact air driven tools, a relatively greater value of striking energy per piston stroke can be obtained.

Another object of the present invention is to provide an improved impact air driven tool wherein the number of piston strokes can be varied from the zero value to the maximum possible value as desired so that the optimum value can be selected to suit to the capacity of a compressor in stock in case of said tool of the present invention being in effect connected with said compressor in stock.

These and other objects and features of the present invention will become apparent from the following description taken in conjunction with preferred embodiments thereof with reference to the attached drawings, in which:

FIG. **1** is a longitudinal sectional view of one embodiment of the present invention with a portion being broken away,

FIG. **2** is a cross-sectional view of a control valve mechanism in said embodiment of the present invention,

FIG. **3** is a longitudinal sectional view of a throttle valve portion, on an enlarged scale, employed in the embodiment shown in FIG. **1**,

FIG. **4** is a longitudinal sectional view, on an enlarged scale, of a rapid exhaust valve portion employed in the embodiment shown in FIG. **1**,

FIG. **5** is a longitudinal sectional view of a modified embodiment of the present invention with a portion being broken away,

FIG. **6** is a cross-sectional view of a control valve mechanism employed in said modified embodiment shown in FIG. **5**,

FIG. **7** is a longitudinal sectional view, on an enlarged scale, of a throttle valve portion employed in the modified embodiment shown in FIG. **5**,

FIG. **8** is a longitudinal sectional view, on an enlarged scale, of a rapid exhaust valve portion employed in the modified embodiment shown in FIG. **5**, and

FIG. **9** is a longitudinal sectional view, on an enlarged scale, of a check valve portion employed in the modified embodiment shown in FIG. **5**.

As illustrated in the attached drawings, the improved impact air driven tool according to the present invention basically comprises a cylinder unit, a piston unit, a chisel unit, and a control valve unit for controlling the flow of compressed air supplied to said cylinder unit.

Referring now to FIG. **1** through FIG. **4** in which one preferred embodiment of the present invention is shown, reference numeral **11** represents a cylinder, **12** represents a top plate secured to an upper end of said cylinder, **13** represents a chisel holder secured to a lower end of said cylinder, **14** represents a chisel and **15** represents a piston slidably received in said cylinder.

Reference numeral **16** is a valve casing secured to a lateral upper portion of said cylinder **11**, in which valve housing a valve body **17** is slidably received. This valve casing **16** is formed with a compressor air supply port **18** to which a nipple **19** is pivotably connected. One end of said nipple **19** remote from said supply port **18** is rigidly connected with an elbow **20** to which a tubular hose connected from a suitable compressor means may be connected.

The valve casing **16** is secured at its right-hand side as viewed from FIG. **2** with a plate member **21** formed therein with a passage **22** communicating with a right-hand opening **24** of a valve chamber **23**.

The valve casing **16** is also provided therein with a limiting valve chamber **26** slidably receiving a limiting valve **25** therein and with a valve chamber **28** having therein a tubular check valve **27** biased by a spring **30** to the left within said valve chamber **28**. This valve chamber **28** is formed at its outer peripheral surface with a tubular gap **29** and at its left-hand portion with a passage **31** communicating with said passage **22**. Thus, said check valve **27** acts to permit the flow of air from the passage **31** to the gap **29**, but to restrict said flow from the gap **29** to said passage **31**.

The plate member **21** is also formed therein with an adjustable needle valve in the form of a throttle valve **32** situated between a passage **33** and a passage **34**, which are also formed within the plate member **21**, for regulating the flow of air passing between said passages **33** and **34**. The passage **33** is communicated with the valve chamber **28** while the passage **34** is communicated with the gap **29**.

The valve body **17** is formed at its right-hand portion with an enlarged diameter portion **35** having a recess at its right-hand extremity in the axial direction thereof, so that when said valve body **17** is moved to the right an annular groove **36** on the inner peripheral surface of the valve chamber **23** can be closed by said enlarged diameter portion **35** while, when said valve body **17** is moved to the left, said annular groove **36** commences to communicate with the opening **24** through a right-hand portion of said chamber **23** and also with said gap **29**.

The valve body **17** is formed about its intermediate portion with a reduced diameter portion **40** which, upon movement of the valve body **17** to the right, acts to communicate between annular grooves **41** and **42** formed on the inner peripheral surface of the valve chamber **23** at a position around said reduced diameter portion **40**. This annular groove **41** is directly communicated with an exhaust port **43** formed in the valve casing **16** and the annular groove **42** is directly communicated with a passage **44** formed as shown in FIG. **1**, in a wall portion of the cylinder **11**.

The valve chamber **23** is also formed on its inner peripheral surface at a left-hand portion next to the annular groove **41** with an annular groove **45** which may be communicated with the annular groove **41** through said reduced diameter portion **40** when the valve body **17** is situated to the left, but blocked of its communication therewith when the valve body **17** is situated to the right. This annular groove **45** is directly communicated with a passage **46** open to the interior of the cylinder **11** at a position below an opening of the passage **39**, as shown in FIG. **1**.

The limiting valve **25** is formed at its intermediate portion with a reduced diameter portion **47** which, upon movement of said valve **25** to the right, acts to communicate between passages **48** and **49** formed on the inner peripheral surface of the valve chamber **26**.

This passage 48 is directly communicated with the gap 29 and the passage 49 is directly communicated with the annular groove 37.

The valve chamber 26 is also formed in its peripheral wall at a position about the right-hand extremity of the limiting valve 47 with a passage 50 and about a left-hand portion of the limiting valve 47 with a passage 51 and a passage 52. The passage 50 is communicated with the annular groove 38 by means of the common passage 39 which is in turn open to the interior of the cylinder 11. The passage 51 is communicated with the annular groove 45 by means of the common passage 46 which is in turn open to the interior of said cylinder 11. The passage 52 may be communicated with the passage 48 through the reduced diameter portion 47 to permit the flow of air to an exhaust port 53 when the limiting valve 25 is moved to the left.

Reference numeral 54 represents a rapid exhaust valve casing secured to an intermediate portion of the cylinder 11. As shown particularly in FIG. 4, this rapid exhaust valve casing 54 is formed with a ventilating port 55 directly communicated with a ventilating hole 68 formed in the wall of the cylinder 11. Within said valve casing 54, a valve chamber 59 is formed for slidably receiving therein a valve member 56 capable of closing and opening the ventilating port 55. It should, however, be noted that the valve member 56 is formed with an auxiliary valve chamber 58 in which an auxiliary valve 57 in the form of a plate member is operatively mounted as shown in FIG. 4.

The valve 56 is formed at its left-hand portion with an opening 60 which may be closed by the auxiliary valve 57 when the latter is moved to the left. The auxiliary valve chamber 58 is formed at its depth with a plurality of holes 61 communicating between the right-hand portion of the auxiliary valve chamber 58 and the ventilating port 55 and thus ventilating hole 68. This valve chamber 58 is also formed at a central portion of its depth with a slight projection which permits, together with a plurality of notches formed on the outer periphery of the auxiliary valve 57, the flow of air from the opening 60 to the holes 61 even when the right-hand surface of the auxiliary valve 57 is contacted with the depth of said valve chamber 58 or the left-hand surface of said projection.

Provided at the left-hand extremity of the valve chamber 59 is an annular cushioning member 62, made of elastic material, having a through hole at its center, said through hole being communicated with a passage 69 which is in turn connected to the passage 44 formed in the wall of the cylinder 11.

However, it should be noted that the valve member 56 and accordingly the valve chamber 59 are stepped to give an enlarged diameter portion on the side adjacent to the ventilating port 55. Therefore, it will thus be understood that, when the valve member 56 is moved to the right, a cavity *b* will be formed between said enlarged diameter portion of the valve chamber 59 and a correspondingly reduced diameter portion of the valve member 56. This cavity *b* is communicated with an exhaust port 65 by means of a small passage 64, the both of the latter being formed in a lower wall portion of the casing 54. At a lower portion of the casing 54 beneath said exhaust port 65, a plurality of small holes 66 are disposed for discharging the exhaust air from the port 65 to the atmosphere.

It should be noted that the valve casing 16 is rigidly secured at its left-hand side as viewed from FIG. 2 with another plate member corresponding to the above-mentioned plate member 21, but the plate member at the left-hand side of the valve casing 16 is provided with an outlet hole communicated with the left-hand portion of the valve chamber 23.

In this arrangement as hereinbefore fully described, the operation of the improved impact air driven tool of the present invention is as follows.

When compressed air is supplied to the supply port 18 of the casing 16 through the elbow 20 and then nipple 19, the compressed air will flow to the annular groove 37 and then to the annular groove 38 communicated therewith by the reduced diameter portion 67 of the valve body 17. However, since the groove 38 is communicated to the passage 39 of which the other end is open to the interior of the cylinder 11, the compressed air thus supplied will cause the piston 15 to move downward.

At the same time, since the groove 37 is communicated with the limiting valve chamber 26 by means of the passage 49 which is at this time communicates with the passage 48 by the reduced diameter portion 47 of the limiting valve 25, the other end of said passage 48 being communicated to the gap 29 around the check valve 27, the same compressed air will be introduced to said gap 29 and via passage 34 directed to the throttle valve 32 formed in the plate member 21.

While the check valve 27 is normally positioned as illustrated in FIG. 2, the air in the passage 34 will pass through a clearance *a* of the throttle valve 32 to the passage 33 and then to the passage 31 passing through the check valve 27. Thereafter, the air in the passage 31 will be introduced to the opening 24 through the passage 22 into the recess formed on the right-hand extremity of the valve member 17 in the axial direction. However, since the throttle valve 32 provides a narrow clearance *a* as shown in FIG. 3, the air is somewhat slowly supplied from the passage 34 into the recess, and the value of pneumatic pressure will, accordingly, slowly increase.

In addition thereto, since a passage communicating the groove 38 to the passage 39 open to the interior of the cylinder 11 is communicated with the passage 50 which is in turn communicated with the right-hand portion of the limiting valve chamber 26, the compressed air will also be supplied to the right-hand extremity of the valve 25 through said passage 50. The compressed air supplied into the interior of the cylinder 11 by means of the passage 39 will then flow into the passage 46, which is in turn introduced against the left-hand extremity of the limiting valve 25 through the passage 51. However, since the working area of the left-hand extremity of the limiting valve 25 is greater than that of the right-hand extremity thereof, the limiting valve 25 is biased to the right even when , as a result, pressure of the compressed air acts on both extremities thereof.

While in this condition, the annular groove 42 in the chamber 23 is communicated with the annular groove 41 by the reduced diameter portion 40 of the valve member 17 and then to the atmosphere through the exhaust port 43 formed in a wall portion of the casing 16. Accordingly, it will be clearly understood that the valve chamber 59 within the rapid exhaust valve casing 54 is communicated to the atmosphere by means of the passage **44** extending from the passage **69** communicated with said chamber **59**. Therefore, as the piston **15** moves downward, the air contained in a lower cylinder cavity defined between the lower extremity of the piston **15** and the upper extemity of the chisel **14** will open the valve member **56** and escape therefrom to the atmosphere through the ventilating port **55**, the exhaust port **65** and then a plurality of the small holes **66**. Thus, the piston **15** is rapidly moved downward to abut against the upper extremity of the chisel **14**.

As a value of pneumatic pressure in the recess at the right-hand extremity of the valve body **17** gradually increases in excess of a value of pneumatic pressure acting on an annular area on the left-hand side of the enlarged diameter portion **35** so as to move the valve body **17** to the right, the valve body **17** commences to move to the left. As soon as the right-hand extemity of the valve body **17** thus passes through an O-ring provided to the right of the annular groove **36**, the valve body will be rapidly moved to the left because pneumatic pressure that has been applied to the annular groove **36** is added to the pneumatic pressure applied through the opening **24**.

Upon completion of the movement of the valve body **17** to the left, the grooves **37** and **42** in the valve chamber **23** are communicated to each other by the reduced diameter portion **67** while communication between the grooves **37** and **38** and communication between the grooves **41** and **42** are respectively cut off. Accordingly, the compressed air supplied to the supply port **18** will flow to the passage **44** through the groove **37** and then the groove **42**, pressing the valve member **56** and the auxiliary valve **57** to the right and passing through the notches on the periphery of the auxiliary valve **57** and then the holes in the depth of the auxiliary valve chamber **58**, and finally be supplied through the ventilating hole **68** by means of the ventilating port **55** into the lower cylinder cavity defined by the lower extremity of the piston and the upper extremity of the chisel. A seal ring provided in the peripheral surface of the right-hand end of the valve member **56** is at this time tightly contacted to the adjacent end surface of the ventilating port **55** so as to prevent the air in the ventilating port from leaking out.

At the same time as hereinbefore described, the grooves **41** and **45** in the valve chamber **23** are also communicated to each other by the reduced diameter portion **40**, permitting the passage **46** to communicate with the exhaust port **43** and then to atmosphere through said grooves **41** and **45**. Accordingly, the air contained in an upper cylinder cavity defined between the upper extremity of the piston **15** and the back of the top plate **12** will be discharged to the atmosphere through the passage **46** that has been communicated with the exhaust port **43**. Thus, the piston **15** commences to move upward.

In addition, when the groove **45** is communicated to the atmosphere, the passage **51** is also communicated to the atmosphere. At this time, a value of pressure in the passage **39** and thus a valve of pressure in the passage **50** communicated therewith are equalized to the atmosphere. Thus, the limiting valve **25** remains to the right.

However, as the piston **15** moves upward and subsequently its upper extremity closes the passage **46**, the remaining air in the upper cylinder cavity will be compressed and subsequently pressure of said compressed air be applied through the passage **50** to the right-hand extremity of the limiting valve **25** to move the latter to the left.

As the limiting valve **25** moves to the left, the passage **48** is communicated by the reduced diameter portion **47** of the valve **25** with the passage **52**, permitting the air in the gap **29** and the groove **36** to be discharged to the atmosphere therethrough by means of the exhaust port **53**.

Thus, as a value of pressure within the gap **29** and the annular groove **36** is equalized to the atmosphere, a value of pressure within the right-hand portion of the valve chamber **23** also reaches atmospheric and, therefore, the valve body **17** is moved to the right by the action of pressure acting on the left-hand extremity of said enlarged diameter portion **35**. As soon as the left-hand extremity passes through an O-ring provided to the right of the groove **36**, communication between the groove **36** and the right-hand portion of the valve chamber **23** will be cut off with subsequent increase of a value of pressure within said right-hand portion of the valve chamber **23**, the increased pressure then acting through the passage **31** to the check valve **27** so as to open the latter. As the check valve **27** is thus opened, the air within the right-hand portion of the chamber **23** can be discharged from the exhaust port **53** in the order through the passage **22**, passage **31**, gap **29**, passage **48** and finally the passage **52**, and, thus, the movement of the valve body **17** to the right completes to establish the condition as shown in FIG. **2**.

As a result, compressed air is again supplied into the upper cylinder cavity while the passage **44** is communicated to the atmosphere.

Accordingly, it will be clearly understood that the valve chamber **59** within the rapid exhaust valve casing **54** is again communicated to the atmosphere by means of the passage **44** extending from the passage **69** communicated with said chamber **59**. Then, in the same manner as has been seen during the previous downward movement of the piston **15** within the cylinder **11**, the air contained in the lower cylinder cavity will again open the valve member **56** and escape therefrom to the atmosphere through the ventilating port **55**, the exhaust port **65** and finally the small holes **66**, while the piston **15** is again abutted against the upper extremity of the chisel **14**.

Subsequently, as the upper extremity of the piston **15** clears the opening of the passage **46** during its downward movement, the compressed air supplied through the passage **39** into the upper cylinder cavity will again flow to the passage **51** by means of the passage **46**, applying its pneumatic pressure to the left-hand extremity of the limiting valve **25** thereby to move the latter to the right. Thus, the limiting valve **25** can be positioned as illustrated in FIG. **2**.

As hereinbefore fully described, so long as compressed air is supplied to the supply port **18** of the improved impact air driven tool of the present invention, the above-mentioned operation of one cycle may be repeated, wherein the piston is fiercely reciprocated within the cylinder to strike on the upper extremity of the chisel and thereby to perform the intended work.

According to the preferred embodiment of the present invention as shown in FIG. 1 through FIG. 4, by adjusting the opening, or a value of the clearance *a*, of the throttle valve **32**, the number of piston strokes per unit time can be varied as desired. Even in the event that the number of piston strokes per unit time is varied, a value of striking energy per piston stroke does not vary at all. The reason therefor will be hereinafter set forth.

It should be noted that the piston **15** within the cylinder **11** has a striking phase wherein the valve body **17** and the limiting valve **25** are positioned as shown in FIG. **2**, a resting phase which continues from the time at which the piston strikes the chisel **14** until the time at which the piston commences its upward movement away from the chisel, and a return phase wherein the upward movement of the piston takes place. However, the resting phase is a time duration of the valve body **17** moving from the right to the left within its valve chamber **23**, commencing at the moment that the piston **15** strikes the chisel **14** and ending at the moment that the piston **15** commences its upward movement away from the chisel.

Accordingly, if the throttle valve **32** is constructed in the form of screw type needle valve as substantially shown in FIG. **3**, a value of pneumatic pressure acting on the right-hand extremity of the valve body **17** can be rapidly increased by adjusting the valve **32** so as to increase a value of the clearance *a*, resulting in the reduction of the time necessary for the valve body **17** to complete its movement from the right to the left, that is to say, duration of the resting phase.

On the contrary, if the throttle valve **32** is adjusted so as to reduce the value of said clearance *a*, the duration of the resting phase may be prolonged.

As hereinbefore described, change of the duration of the resting phase results in the change of the number of piston strokes per unit time. It will be thus understood that the adjustment of the throttle valve merely affects the duration of the resting phase independent of the striking phase and the return phase. Therefore, the number of the piston strokes per unit time can be advantageously adjusted without any substantial reduction of the amount of the striking energy obtained by the improved impact air driven tool of the present invention.

Referring now to FIG. **5** through FIG. **9** in which a modified embodiment of the present invention is shown, reference numeral **71** represents a cylinder, **72** represents a top plate secured to an upper end of said cylinder, **73** represents a chisel holder, **74** represents a chisel, and **75** represents a piston slidably received in said cylinder.

Reference numeral **76** represents a valve casing secured to a lateral upper portion of said cylinder **71**, in which valve casing a valve body **77** is slidably received. This valve casing **76** is formed with a compressed air supply port **78** to which a nipple **79** is pivotably connected. One end of said nipple **79** remote from said port **78** is rigidly connected with an elbow **80** to which a tubular hose connected from a suitable compressor means may be connected. The valve casing **76** is secured at its both right-hand and left-hand sides as viewed from FIG. **6** with a pair of plate members **81** and **92**, one of which or the right-hand plate member **81** being formed therein with a passage **82** communicated with an opening **84** of a valve chamber **83** in which said valve body **77** is slidably received.

The valve casing **76** is also provided therein with a time lag valve chamber **86** in which a time lag valve **85** is slidably received and with a valve chamber **88** in which a check valve **87** is provided. Provided around the outer periphery of said valve chamber **88** is an annular gap **89**. The chambers **88** and **86** are connected to each other by a passage **91**. The check valve **87** is normally biased to the right within its valve chamber **88** so as to permit the flow of air from the passage **91** to the gap **89**, but to restrict the flow of air from the gap **89** to the passage **91**.

The other or left-hand plate member **92** is provided therein with a throttle valve **93** in the form, for example, of an adjustable needle valve and at a suitable position with an exhaust hole communicating between the left-hand portion of the chamber **83** and the atmosphere.

The throttle valve **93** is positioned between a passage **94** communicated with the valve chamber **88** and a passage **95** communicated with the gap **89**, so as to act to regulate the flow of air therebetween.

The valve body **77** is formed at its intermediate portion with a reduced diameter portions **103** and **140** and at its right-hand end with an enlarged diameter portion **96** which is in turn formed at its right-hand extremity with a circular recess in the axial direction thereof. The valve chamber **83** is provided on its inner peripheral surface with annular grooves **97** and **98** which can be isolated from each other by the enlarged diameter portion **96** as the valve body **77** is moved to the left, said passage **98** being in turn connected with a passage **99** open to the interior of the cylinder **71** and said passage **97** being in turn connected with the supply port **78**.

This valve chamber **83** is also formed on a left-hand inner peripheral surface with a plurality of annular grooves **100**, **101** and **102**, the grooves **100** and **101** being communicated to each other by the reduced diameter portion **103** of the valve body **77** when the latter is moved to the left while the grooves **101** and **102** being communicated to each other by said reduced diameter portion of the valve body **77** when the latter is moved to the right. The groove **100** is in turn connected with a passage **104** open to the interior of the cylinder **71** at a position below the opening of the passage **99** formed on the inner peripheral surface of the cylinder **71**, the groove **101** is in turn connected with an exhaust port **105** formed in the casing **76** and the groove **102** is in turn connected with a passage **106** formed in a wall portion of the cylinder **71**.

The time lag valve **85** is formed at its intermediate portion with a reduced diameter portion **107** which, upon movement of said valve **85** to the left, acts to communicate between passages **108** and **109** formed on the inner peripheral surface of the valve chamber **86**. The passage **108** is directly connected with an exhaust port **110**. To the left of said passage **108**, a passage **111** communicating between the valve chamber **86** and a passage **112** which is in turn connected to a passage **95** formed in the plate member **92**.

The valve chamber **86** is also formed at its right-hand portion with a passage **113** connected to the groove **97**, the right-hand portion **114** of the chamber **86** being also connected to said groove **97**. The right-hand portion **114** is designed to slidably receive a right-hand reduced diameter portion **115** of the time lag valve **85** therein, the diameter of said reduced diameter portion **115** being smaller than that of the left-hand extremity of the valve body **85**. The right-hand portion is provided on its left-hand inner peripheral surface with an O-ring, to the left of which O-ring the valve chamber **86** is somewhat enlarged to give its diameter greater than that of the right-hand portion **114**. About the boundary between said portion **114** and that enlarged portion of the valve chamber **86**, an exhaust hole communicating between that enlarged portion of the chamber **86** to the atmosphere is provided.

The cylinder **71** is provided on its inner peripheral surface at a position below the opening of the passage **104** formed thereon with another opening in which a limiting valve operating member **116** is collapsibly mounted in such a manner as to project a portion thereof toward the interior of the cylinder **71** unless the projected portion is backwardly retracted by the piston **75**. This operating member **116** is in the form of a ball and, as shown in FIG. 9, acts to operate a limiting valve **118** in a valve chamber **117** formed within a limiting valve casing **145** formed in the cylinder wall. The limiting valve **118** is normally biased toward the operating member **116** by a spring **119** and will operate when the operating member **116** is collapsed by the piston **75**.

The valve chamber **117** is formed about its outer periphery with a passage **120** communicated with the passages **111** and **112** within the valve casing **76** and the passage **95** in the plate member **92** by means of an annular cavity **121** formed in said valve casing **117**.

This valve chamber **117** is also formed at its depth with a valve seat **122** to which the limiting valve **118** is seated by the spring **119**. Provided around said valve seat **122** is a passage **123** communicated with an exhaust port **125**, formed in the valve casing **76**, through a passage **124** formed in the cylinder wall. Provided adjacent to the left-hand extremity of the limiting valve **118** is a cavity **141** formed in the valve casing **76** in communication with the annular groove **97** within the valve chamber **83** by means of a passage **146**. The limiting valve **118** is also formed at its left-hand extremity with a recess **142** of a desired depth in communication with a passage **143** which is in turn connected with the annular cavity **121** by means of a passage **144**, the both passages **143** and **144** being formed within the valve casing **145** at a position adjacent to the left-hand extremity of the limiting valve **118**.

Reference numeral **126** represents a rapid exhaust valve casing secured to the cylinder **71**. As shown particularly in FIG. 8, this rapid exhaust valve casing **126** is formed with a ventilating port **127** directly communicated with a ventilating hole **146** formed in the wall of the cylinder **71**. Within said valve casing **126**, a valve chamber **129** is formed for slidably receiving therein a valve member **128** capable of closing and opening the ventilating port **127**. The valve member **128** is formed with an auxiliary valve chamber **130** in which an auxiliary valve **131** in the form of a plate member is operatively mounted.

The valve member **128** is formed at its left-hand portion with an opening **132** which may be closed by the auxiliary valve **131** when the latter is moved to the left. The auxiliary valve chamber **130** is formed at its depth with a plurality of holes **133** communicating between the right-hand portion of the auxiliary valve chamber **130** and the ventilating port **127** and thus the ventilating hole **146**. This valve chamber **129** is also formed at a central portion of its depth with a slight projection which permits, together with a plurality of notches formed on the outer periphery of the auxiliary valve **131**, the flow of air from the opening **132** to the holes **133** even when the right-hand surface of the auxiliary valve **131** is contacted with the depth of said valve chamber **129** or the left-hand surface of said projection.

Provided at the left-hand extremity of the valve chamber **129** is an annular cushioning member **134**, made of elastic material, having a through hole at its center, said through hole being communicated with a passage **135** which is in turn connected to the passage **106** formed in the wall of the cylinder **71**.

However, it should be noted that the valve member **128** and accordingly the valve chamber **129** are stepped to give an enlarged diameter portion on the side adjacent to the ventilating port **127**. Therefore, it will thus be understood that, when the valve member **128** is moved to the right, a cavity *d* will be formed between said enlarged diameter portion of the valve chamber **129** and a correspondingly reduced diameter portion of the valve member **128**. This cavity *d* is communicated with an exhaust port **138** by means of a small passage **137**, the both of the latter being formed in a lower wall portion of the casing **126**. At a lower portion of the casing **126** beneath said exhaust port **138**, a plurality of small holes **139** are disposed for discharging the exhaust air from the port **139** to the atmosphere.

While in the arrangement of the modified embodiment of the present invention as hereinbefore fully described, the improved impact air driven tool according thereto may function in such a manner as hereinafter set forth.

When compressed air is supplied to the supply port **78** of the casing **76** through the elbow **80** and then nipple **79**, the compressed air will flow to the annular groove **97** and then to the annular groove **98** communicated therewith by the reduced diameter portion **140** of the valve body **77**. However, since the groove **98** is communicated to the passage **99** of which the other end is open to the interior of the cylinder **71** at a position above the upper extremity of the piston **75**, the compressed air thus supplied will cause the piston **75** to move downward.

At the same time, the annular groove **102** connected to the passage **135** of the rapid exhaust valve casing **126** by means of the passage **106** is communicated by the reduced diameter portion **103** of the valve body **77** with the annular groove **101** communicated in turn to the exhaust port **105**. Accordingly, it will be clearly understood that, as the piston **75** is downwardly moved, the air contained in a lower cylinder cavity defined between the lowermost end surface of said piston and the uppermost end surface of the chisel **74** will press the valve member **128** whereby said air can be discharged to the atmosphere through the exhaust port **138** and then the holes **139**, resulting in the rapid downward movement of the piston to strike the chisel **74**.

The annular groove **97** is then communicated with the right-hand portion **114** of the valve chamber **86** and the groove **113** which is in turn communicated with the time lag valve chamber **86**. Accordingly, the compressed air will also act on the right-hand reduced diameter portion **115** of the time lag valve **85** to render the valve **85** to move to the left and thereby to close the passage **113**, as shown in FIG. **6**. In addition, since the groove **97** is communicated with the cavity **141** of the limiting valve casing by means of the passage **146**, the pneumatic pressure will also act on the left-hand extremity of the valve **118** and then flow to the annular cavity **121** in the order through the recess **142**, passage **143** and passage **144**. Then, the air in the annular cavity **121** then in part flow to the passage **95** in the plate member **92** and thus to the passage **94** through a clearance *c* of the throttle valve **93**. The air in the passage **94** is introduced against the left-hand extremity of the time lag valve **85** through the check valve **87** by means of the passage **91**. Also, the compressed air in the passage **85** will in part flow into the gap **89**, acting on the check valve **87**.

Accordingly, the compressed air is slowly accumulated within a left-hand portion of the valve chamber **88** and the passage **91** via the clearance *c* of the throttle valve.

Although the compressed air acts on the both extremities of the time lag valve **85** as hereinbefore described, the time lag valve **85** is positioned to the left until a value of pressure of the compressed air acting on the left-hand extremity of the valve **85** increases over that of pressure acting on the right-hand reduced diameter portion **115** of said valve. Upon increase of the value of pressure acting so as to move the valve **85** to the right in excess of the value of pressure acting so as to move the valve **85** to the left, the valve **85** commences to move to the right. As soon as the left-hand extremity of the valve **85** passes through the O-ring positioned at the left side of the valve chamber **86**, it can be rapidly moved to the right as pressure in the passage **112** is also applied through the passage **111** to the left-hand extremity thereof, until the right-hand reduced diameter portion **115** is abutted against the cushioning member provided at the depth of the right-hand portion **114** of the chamber.

As the time lag valve **85** is thus moved to the right, the reduced diameter portion **107** of said valve communicates the passage **109** with the passage **113**. However, it should be noted that the compressed air from the groove **97** always exists in the passage **113** throughout the operation of the impact air driven tool of the present invention. Therefore, upon communication between the passages **109** and **113**, the air flows into the passage **109** from the passage **113** and the to the right-hand portion of the chamber **83** through the opening **84** by means of the passage **82** communicated therewith. This air thus supplied then acts on the right-hand extremity of the enlarged diameter portion **96** of the valve body **77** so as to move the latter to the left.

As the valve body **77** is moved to the left, the reduced diameter portion of the valve **77** communicates the groove **101** with the groove **100** while an intermediate portion of said valve **77** isolates the grooves **101** and **102** and the reduced diameter portion **140** of the valve **77** communicates the groove **97** with the groove **102** while the enlarged diameter portion **96** thereof closes the groove **98**. Subsequently, the air in the groove **97** is supplied to the passage **106** through the groove **102** and then to the passage **135**, then passing through the notches on the periphery of the auxiliary valve **131** and then the ventilating port **127** into the lower cylinder cavity defined between the lowermost end of the piston and the uppermost end of the chisel. Thus, it will be understood that the piston **75** is upwardly moved thereby. At this time, the seal ring provided in the peripheral surface of the right-hand end of the valve member **128** is tightly contacted to the adjacent end surface of the ventilating port **127** so as to prevent the air in the ventilating port from leaking out.

While in this condition as hereinbefore described, the air contained in the upper cylinder cavity is discharged to the atmosphere in the order through the passage **104**, the grooves **100** and **101** communicated to each other, and the exhaust port **105** of the casing **76**.

However, as the piston **75** is upwardly moved a sufficient distance, the limit valve operating member **116** is backwardly retracted by the uppermost end of said piston. Rectraction of said member **116** will cause the limit valve **118** to move to the left, compressing the spring **119** while closing the passage **143** in the valve **118**. At this time, the passage **124** communicated to the atmosphere commences to communicate with the valve chamber **117**. However, since this valve chamber **117** is communicated with the left-hand portion of the valve chamber **86** through the passage **120**, the annular groove **121**, and the passages **112** and **111**, the air in said portion of the valve chamber **86** is exhausted and the time lag valve **85** is moved to the left under the influence of the pneumatic pressure always existing in the right-hand portion **114** as supplied from the groove **97**. Also, upon communication of the passage **112** with the exhaust port **125**, the air in the passage **95** and the gap **89** is exhausted while the air contained in the check valve **87** and the passage **91** presses the check valve **87** so as to open the latter so that this air is also exhausted through the exhaust port **125** by means of the gap **89**.

Thus, when the time lag valve **85** is moved to the left as hereinbefore described, the passages **108** and **109** are communicated to each other and the air contained in the right-hand portion of the valve chamber **83** can be discharged to the atmosphere via the opening **84**, the passage **82** and then through the exhaust port. Accordingly, the valve body **77** is returned to the right with its enlarged diameter portion **96** being applied with pneumatic pressure in the left-hand portion of the valve chamber **83**, thus commencing the next cycle of operation.

As hereinbefore fully described, so long as compressed air is supplied to the supply port **78** of the improved impact air driven tool of the present invention, the above-mentioned cycle of its operation may be repeated, wherein the piston **75** is fiercely reciprocated within the cylinder to strike on the upper extremity of the chisel **74** and thereby to perform the intended work.

Even in the modified embodiment of the impact air driven tool of the present invention, the number of piston strokes per unit time can be varied by adjusting the opening, or the value of the clearance *c*, of the throttle valve **93** as in the first mentioned embodiment of the present invention. Similarly, even in the event that the number of piston strokes per unit time is varied, the value of striking energy per piston stroke does not vary at all.

More particularly, it should be noted that the piston **75** within the cylinder **71** has a striking phase, a resting phase and a return phase throughout each cycle of operation. However, according to the modified embodiment of the present invention, by adjusting the duration of the resting phase of the piston, the number of piston strokes per unit time can be varied without affecting the striking phase and the return phase.

In other words, the resting phase of the piston **75** represents a duration of time between the time at which the piston strikes the chisel and the time at which said piston commences its upward movement away from said chisel. However, this time duration may be determined by the time necessary for the time lag valve **85** to complete its movement to the right after the piston strikes the chisel.

In order to cause the time lag valve **85** to move from the left to the right, it is necessary to increase the value of pneumatic pressure acting through the clearance *c* of the throttle valve **93** on the left-hand extremity of said valve **85**. Accordingly, it will be clearly understood that the time necessary for the time lag valve **85** to complete its movement to the right after the piston strikes the chisel can be varied by adjusting the size of the clearance *c* and thereby to adjust the rate of increase of the pneumatic pressure acting therethrough on the left-hand extremity of said time lag valve **85**.

Accordingly, if the throttle valve **73** is constructed in the form of screw type needle valve as substantially shown in FIG. 7 in order to permit the adjustment of the size of the clearance *c*, the number of piston strokes per unit time can be varied through controlling the duration of the resting phase of the piston.

In addition thereto, in the modified embodiment of the present invention, the impact air driven tool is designed such that the limiting valve **118** is actuated to bring the time lag valve **85** into the striking phase during the return movement of the piston **75** away from the chisel **74** and thereby to bring the valve body **77** into the striking phase through the shifting movement of said valve **85**. Therefore, retardation of the shifting movement of the valve body **77** with respect to the movement of the piston **75** does not take place with smooth, rapid shift of the movement of the piston from the return phase to the striking phase.

What I claim is:

1. An air driven impact tool comprising a cylinder with a closed upper end, a chisel closing the bottom end of said cylinder, an impact piston movable within said cylinder and forming an upper cavity between said piston and said upper end and a lower cavity between said piston and said chisel; a casing attached to said cylinder at the upper portion thereof, a main valve body movably mounted in said casing, a limiting valve movably mounted in said casing, an adjustable throttle valve mounted within said casing, a one-way check valve movably mounted in said case, a compressed air supply port extending into said casing and acting to bias said main valve body in a first direction, a first passage communicating said compressed air to said upper cavity when said main valve body is in said first direction, a second passage communicating compressed air from said upper cavity to urge said limiting valve in a given direction; an exhaust valve connected to said cylinder below said casing, an opening communicating said exhaust valve to said lower cavity, a third passage from said casing to said exhaust valve communicating said lower cavity to atmosphere when said main valve body is in said first direction; said piston being forced downwardly to strike said chisel when said compressed air is supplied to said upper cavity; a channel through said adjustable throttle valve to slowly supply said compressed air to bias said main valve body in a direction opposite said first direction, whereby a predetermined time after said piston strikes said chisel said main valve body is moved in said opposite direction, said first passage being blocked from communication with said compressed air and exhausted to atmosphere when said main valve body is in said opposite direction, and said third passage being connected to said compressed air supply when said main valve body is in said opposite direction such that compressed air is supplied to said lower cavity.

2. An air driven impact tool comprising a cylinder with a closed upper end, a chisel closing the bottom end of said cylinder, an impact piston movable within said cylinder and forming an upper cavity between said piston and said upper end and a lower cavity between said piston and said chisel; a casing attached to said cylinder at the upper portion thereof, a main valve body movably mounted in said casing, time lag valve movably mounted in said casing, a one-way check valve movably mounted in said casing, an adjustable throttle valve mounted within said casing, a limit valve operating member mounted within said casing and having a member extending into said upper cavity, a compressed air supply port extending into said casing and acting to bias said main valve body in a first direction, a first passage communicating said compressed air to said upper cavity when said main valve body is in said first direction; an exhaust valve connected to said cylinder below said casing, an opening communicating said exhaust valve to said lower cavity, a second passage from said casing to said exhaust valve communicating said lower cavity to atmosphere when said main valve body is in said first direction; said piston being forced downwardly to strike said chisel when said compressed air is supplied to said upper cavity; a channel through said adjustable throttle valve to slowly supply said compressed air to urge said time lag valve in a given direction, whereby a predetermined time after said piston strikes said chisel said tine lag valve and said main valve body are moved in directions opposite to said given direction and first direction, respectively, said first passage being blocked from communication with said compressed air and exhausted to atmosphere when said main valve body is in said opposite direction, said second passage being connected to said compressed air supply when said time lag valve is in said opposite direction such that compressed air is supplied to said lower cavity, and said member of said limit valve operating member being movable upon contact by said piston when said piston moves upwardly.

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