

July 15, 1969

W. L. CHICHESTER

3,455,322

PRESSURE COMPENSATED DIVERTER VALVE

Filed Dec. 30, 1966

FIG. 1

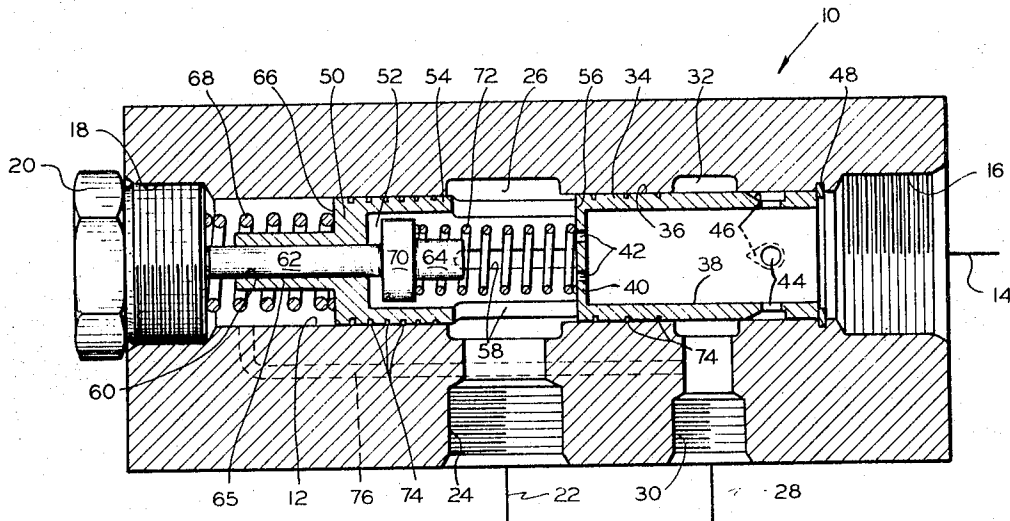
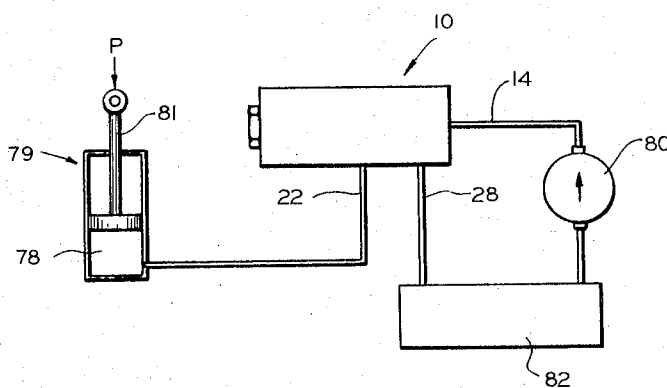


FIG. 2



INVENTOR

WILLARD L. CHICHESTER

BY *Orson J. Allen*
Boettcher & Deemer

ATTORNEYS

1

2

3,455,322

PRESSURE COMPENSATED DIVERTER VALVE
Willard L. Chichester, Battle Creek, Mich., assignor to
Clark Equipment Company, a corporation of Michigan
Filed Dec. 30, 1966, Ser. No. 606,186
Int. Cl. G05d 7/00, 9/00
U.S. Cl. 137—108 14 Claims

ABSTRACT OF THE DISCLOSURE

A pressure compensated diverter valve for diverting fluid flow from a fluid inlet passage to a fluid relief passage when the fluid pressure in the fluid outlet passage reaches a predetermined value. First and second valve spool means are disposed within a chamber in the valve housing with the second valve spool being adapted to urge the first valve spool to a first position wherein it blocks flow from the inlet passage through the relief passage when the fluid pressure in the fluid outlet passage mined value the second valve spool means is moved to a position to allow the first valve spool to divert flow from the inlet passage through the fluid relief passage, thereby effecting a reduced fluid flow through the outlet passage.

It is a common practice in the material handling art to utilize hydraulically actuated cylinder-piston assemblies to effect raising and lowering of various weight loads when moving materials between storage locations or from a storage area to a work area. For example, it is a known practice to utilize a hydraulically actuated piston assembly to effect raising and lowering of the lift fork on an industrial lift truck. Reference may be had to U.S. Patent No. 3,213,967, issued Oct. 26, 1965, and assigned to the assignee of the present invention. It is desirable to provide such lift trucks with high speed lift systems to allow maximum lift speed under certain load conditions. Many known hydraulic systems for effecting raising and lowering of the lift forks on lift trucks employ conventional fixed displacement hydraulic pumps in combination with open center directional control valves. These known systems exhibit several disadvantages, one disadvantage being that after selecting the correct pump delivery required for maximum lift speed under no-load conditions, the lift speed is too great under loaded conditions.

Accordingly, it is a primary object of the present invention to provide a flow control valve assembly which includes novel means for diverting fluid from an inlet passage to a fluid relief passage when the pressure within a fluid outlet passage reaches a predetermined value.

Another object of the present invention is to provide a flow control valve which finds particular application in combination with a conventional fixed displacement pump, and which control valve serves to divert fluid flow from the pump to a relief passage when the fluid pressure within the outlet passage of the valve reaches a predetermined value.

Another object of the present invention is to provide a pressure compensated diverter valve which may be readily operatively associated with a conventional fixed displacement pump and a cylinder-piston assembly such that the valve will allow a maximum rate of extension of the piston under no-load conditions while diverting fluid flow from the cylinder-piston assembly under predetermined load conditions to thereby reduce the rate of extension of the piston member.

A further object of the present invention is to provide a pressure compensated diverter valve employing first and second valve spool means, with the second valve

spool being adapted to preclude movement of the first valve spool until a predetermined outlet pressure is attained whereupon the first valve spool may be moved to a position to divert fluid flow from the inlet passage to a fluid relief passage.

Another object of the present invention is to provide a diverter valve as described wherein the first valve spool means includes means for effecting a pressure differential across the first valve spool, which pressure differential serves to effect movement of said first valve spool to a position to divert flow from the inlet passage when the pressure in the outlet passage reaches a predetermined value.

Another object of the present invention is to provide a pressure compensated diverter valve which is highly efficient in operation and which may be readily operatively associated with a conventional fixed displacement pump to provide the characteristics of a variable displacement hydraulic pump at a much lower cost.

In a preferred embodiment of a flow control diverter valve in accordance with the present invention, a housing member having a cylindrical chamber therein is provided with fluid inlet, fluid outlet, and fluid relief passages in communicating relation with the cylindrical chamber. First and second valve spool means are slidably disposed within the cylindrical chamber with the first valve spool means including flow orifices to allow fluid flow between the inlet and outlet passages, and metering grooves and apertures to allow selected fluid flow between the inlet and relief passages. The second valve spool is adapted to urge the first valve spool to a position wherein flow between the inlet and relief passages is blocked, while being movable at a predetermined outlet pressure to allow the first valve spool to effect fluid flow between the inlet and relief passages. A spring means is provided to urge the first valve spool to the relief passage flow blocking position independent of the second valve spool, with the spring force being overcome by a predetermined pressure differential across the flow orifices. The present invention thus provides a flow control valve which effects a first fluid flow until such time as the pressure within the fluid outlet passage of the valve reaches a predetermined value whereupon the valve will cause a portion of the fluid entering the valve to be diverted through a fluid relief passage.

Further objects and advantages of my invention, together with the organization and manner of operation thereof may best be understood by reference to the following description, taken in conjunction with the accompanying drawing, in which:

FIGURE 1 is a median vertical sectional view through a diverter valve constructed in accordance with the present invention; and

FIGURE 2 is a schematic representation of one application of the diverter valve of the present invention.

Referring now to FIGURE 1, a flow control valve or flow diverter valve, designated generally by reference numeral 10, constructed in accordance with the present invention is illustrated as including a housing or body member 11 having a cylindrical chamber 12 therein. The cylindrical chamber 12 is in axial communicating relation with a fluid inlet passage 14 provided in the body member 11. The body member 11 is internally threaded at 16 to receive a conventional fitting for purposes of coupling the diverter valve into a hydraulic circuit. The body member 11 includes a threaded aperture 18 at the end of the chamber 12 opposite the inlet passage 14. Threaded aperture 18 is in axial alignment with chamber 12 and receives a threaded plug 20 therein to close the adjacent end of the chamber. It will be understood that the end of the body member 11 adjacent the threaded aperture 18 may be

closed as an integral portion of the the body member, thereby eliminating the threaded plug 20. However, the provision of the threaded plug 20 facilitates manufacture of the present valve device and provides a means for ready assembly of the valve components within the chamber 12.

The body member 11 includes a fluid outlet passage 22 having an internal threaded peripheral portion 24 to threadedly receive a conventional fitting in similar fashion to the above described threaded inlet passage 14. The fluid outlet passage 22 communicates with an annular flow passage 26 formed in the peripheral surface of the chamber 12. Body member 11 further includes a fluid relief passage 28 having an internal threaded peripheral surface 30 to receive a conventional fitting for connecting the fluid relief passage to a fluid reservoir or other fluid receptacle 82 (FIGURE 2). The fluid relief passage 28 communicates with an annular flow passage 32 formed in the cylindrical chamber 12. The annular flow passages 26 and 32 are spaced along the longitudinal axis of the cylindrical chamber 12 away from the inlet passage 14.

A first valve spool means comprising a valve sleeve member 34 is disposed within the cylindrical chamber 12 and has a cylindrical outer peripheral surface 36 having a diameter substantially identical to that of the cylindrical chamber 12 to allow sliding movement of the valve member along the longitudinal axis of the cylindrical chamber. The valve member 34 includes a central cylindrical cavity 38 which is opened at one end thereof so as to be in continual fluid communication with the fluid inlet passage 14. The valve member 34 has an end wall means portion 40 provided with a plurality of fluid flow orifices 42 which allow restricted fluid flow therethrough and thus establish fluid communication between the fluid inlet passage 14 and the outlet passage 22, as will become apparent hereinbelow. It will be understood that fluid flow through the flow orifices 42 in the valve member 34 will be restricted somewhat and thereby creates a pressure drop through the orifices, thus effecting a pressure differential which, acting over the effective areas of the opposite surfaces of end portion 40, works against a compression spring 72 as will be more fully explained hereinbelow.

The valve sleeve member 34 further includes a plurality of radially disposed apertures 44 which are positioned to allow fluid flow between the inlet passage 14 and the relief passage 28 when the valve member 34 is moved to a selected position within chamber 12 as will be more fully described below. The outer peripheral surface 36 of the valve member 34 has a plurality of metering notches or grooves 46 provided therein with each metering groove being disposed adjacent an aperture 44. The metering grooves 46 are generally V-shaped in cross section, each metering groove having a progressively reduced volume when considered in a direction away from its corresponding aperture 44. A stop means comprising a conventional snap ring 48 is received within a suitable mating groove provided in the peripheral surface of cylindrical chamber 12 and is spaced axially from the annular flow passage 32 such that when the valve member 34 is positioned against the snap ring 48, the valve member will block fluid communication between the fluid inlet passage 14 and the fluid relief passage 28.

A second valve spool means 50 having an outer diametrical configuration substantially identical to that of the cylindrical chamber 12 is slidably received within the cylindrical chamber in axial alignment with the first valve spool means 34. The second valve spool means 50 includes a generally cylindrical center cavity 52 which thereby defines an annular wall portion 54 having an end surface 56 adapted to abut the outer surface of the wall portion 40 of the first valve spool means 34. A plurality of elongated apertures 58 are provided in the annular wall portion 54 which intersect the end surface 56 thereof. The elongated apertures 58 allow continual fluid communication between the inlet passage 14 and the fluid outlet passage 22 through the flow orifices 42 in wall portion 40 of the first valve

spool means 34. The second valve spool means 50 includes an axially extending bore 60 therethrough which slidably receives the shaft portion 62 of a spring holder member 64. A reduced diametrical rearward portion 65 of the second valve spool means 50 combines with a shoulder portion 66 on the second valve spool to form a spring guide to receive one end of a coil compression spring 68 disposed between the shoulder portion 66 and the inner end surface of the plug member 20. The coil spring 68 serves to resiliently urge the end surface 56 of the second valve spool means 50 against the end wall 40 of the first valve spool means 34, and thus, urges the first valve spool against the stop ring means 48.

The spring holder member 64 includes an enlarged annular portion 70 which forms a spring seat for a coil compression spring 72 disposed between the annular portion 70 of the spring holder member and the outer surface of the wall portion 40 of the valve member 34. The outer end of the shaft portion 62 of the spring holder abuts the inner adjacent end surface of plug member 20 to maintain the annular portion 70 in relative fixed position within the cylindrical chamber 12. The coil compression spring 72 serves as an additional means to urge the valve member 34 against stop ring 48, the force exerted by spring 72 being independent of the position of the second valve spool means 50.

Preferably, a plurality of annular hydraulic pressure grooves 74 are formed in the peripheral surfaces of the first and second valve spool means 34 and 50, respectively. The hydraulic pressure grooves 74 assist in maintaining hydraulic balance of each of the valve spool means and minimize leakage between the peripheral surfaces of the valve spool means and the cylindrical chamber 12. A flow passage 76 is provided in the body member 11 to allow any fluid flow past the second valve spool means 50 to be returned to the fluid relief passage 28.

Having thus described the elements comprising a preferred embodiment of a diverter valve in accordance with the present invention, its operation will now be briefly described, reference being made to FIGURE 1 taken in conjunction with FIGURE 2. Assume, for purposes of illustration, that the fluid diverter valve body member 11 has appropriate fluid conduits secured thereto as by conventional fittings threadedly secured to the fluid inlet passage 14, the fluid outlet passage 22 and the fluid relief passage 28; that the fluid outlet passage 22 is coupled to the variable volume pressure chamber 78 of a cylinder-piston assembly 79; that the fluid inlet passage 14 is coupled to a fixed displacement hydraulic pump 80; and that the relief passage 28 is coupled to a conventional fluid reservoir 82. It will be understood that in such an installation fluid flow from the inlet passage 14 outwardly through the outlet passage 22 to the pressure chamber 78 is required to effect extension of the piston member 81 and that accordingly, the pressure within the pressure chamber, and thus the pressure in the fluid outlet chamber 22, will be dependent upon the load 9 on the outer assuming a non-compressible fluid, will be independent of the load upon the piston. The present flow diverter valve provides a means for diverting fluid flow from the inlet passage 14 through the relief passage 28 at a predetermined outlet pressure to thereby reduce the volume of oil introduced into the pressure chamber 78 of the cylinder-piston assembly 79 through the outlet passage 22 and thus reduce the rate of extension of the piston member 81.

The compression spring 68 is selected such that the second valve spool means 50 will be moved rearwardly away from the end wall 40 of the valve member 34 when the pressure within outlet passage 22 reaches a predetermined value, that valve being determined by the load P on the piston member 81 at which it is desired to reduce the rate of extension of the piston member. The compression spring 72 is selected such that after the second valve spool means 50 is moved away from the valve member 34, the pressure differential created by the pres-

sure drop across the flow orifices 42 will act against the effective area of the wall portion 40 and begin to compress the spring 72 and thereby allow the metering grooves 46 to communicate with the annular flow passage 32. At this time, fluid flow will be diverted from the inlet passage 14 to the relief passage 28 to thus reduce the volume of fluid passing to the pressure chamber 78 of the cylinder-piston assembly 79.

When the load upon the piston 81 in the cylinder-piston assembly 78 is light and it is desired to extend the piston rapidly, the elements of the diverter valve will be positioned as shown in FIGURE 1. The second valve spool means 50 is resiliently urged against the end 40 of the first valve spool means 34 by the coil compression spring 68, thus urging the first valve spool means 34 to a first position against the stop ring 48 wherein it completely blocks fluid flow between the inlet passage 14 and the fluid relief passage 28. In this stage, all of the fluid flow from the inlet passage 14 will be passed through the flow orifices 42 in the end portion 40 of the valve member 34, through the elongated apertures 58 in the second valve spool means 50, and through the outlet passage 22 to the piston assembly 79. During this time, the second coil compression spring 72 also resiliently urges the first valve spool means 34 against the stop ring 48. When the load upon the piston member of the cylinder-piston assembly is increased to the point where it is desired that the rate of outward extension of the piston be substantially reduced as above described, the fluid pressure within the outlet passage 22, and thus the pressure in the cavity 52 of the second valve spool means 50, will cause the second valve spool means to move away from the first valve spool means 34 through compression of the compression spring 68. The first valve spool means 34 will thereafter be urged toward the stop ring 48 solely by the coil compression spring 72. The pressure drop across the flow orifices 42 creates a pressure differential acting against the compression spring 72, having been selected such that it will be compressed when the pressure differential across the flow orifice 42 reaches a predetermined value, will be so compressed by the first valve spool means 34 when the said predetermined pressure differential is attained, whereupon the first valve spool will move to the left, as viewed in FIGURE 1. As the first valve spool means 34 moves to the left, the metering grooves 46 will intersect the annular flow passage 32 thereby allowing fluid from the inlet passage 14 to pass through the radially disposed apertures 44 and the metering grooves 46 outwardly through the fluid relief passage 28. Thus, it can be seen that the subject diverter valve may be utilized to effect a first fluid flow under a first load or pressure condition, for example, under a light load, while reducing the fluid outlet flow under heavy loads, thus providing many of the features of a variable displacement hydraulic pump at a much lower cost.

While a preferred embodiment of my invention has been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made therein without departing from the invention in its broader aspects, and, therefore, the appended claims are intended to cover all such changes and modifications as fall within the true spirit and scope of my invention. Further, while I have described my invention as being particularly suitable for use in combination with a cylinder-piston arrangement, it will be understood that my invention is equally well suited for application in any fluid system wherein flow diversion is desirable as a function of the fluid outlet pressure.

I claim:

1. A pressure compensated diverter valve comprising, in combination, a body member having a chamber therein and including fluid inlet, fluid outlet and fluid relief passages communicating with said chamber, first valve spool means disposed within said chamber and adapted for movement between a first position wherein fluid com-

munication between said fluid inlet passage and said fluid relief passage is blocked, and a second position wherein said fluid inlet passage is in fluid communication with said fluid relief passage, second valve spool means disposed within said chamber and adapted for movement between a position wherein it urges said first valve spool toward said first position, and a position to allow movement of said first valve spool to said second position, said second valve spool being in fluid communication with said fluid outlet passage and further adapted for movement to said position to allow movement of said first valve spool to said second position when the fluid pressure within said fluid outlet passage reaches a predetermined value and means for urging said first valve spool to said first position when the fluid pressure within said fluid outlet passage is above said predetermined value and below the fluid pressure which will effect movement of said first valve spool to said second position.

2. A pressure compensated diverter valve comprising, in combination, a body member having a chamber therein and including fluid inlet, fluid outlet and fluid relief passages communicating with said chamber, first valve spool means including a valve sleeve member disposed within said chamber and having a peripheral configuration substantially identical to the cross sectional configuration of said chamber, said valve sleeve member being axially movable within said chamber between a first position wherein fluid communication between said fluid inlet passage and said fluid relief passage is blocked, and a second position wherein said fluid inlet passage is in fluid communication with said fluid relief passage, said valve member including a central cavity therein in continual fluid communication with said fluid inlet passage and having metering grooves therein adapted to allow fluid communication between said fluid inlet passage and said fluid relief passage when said first valve spool means is moved to said second position, and second valve spool means disposed within said chamber and adapted for movement between a position wherein it urges said valve sleeve member toward said first position, and a position to allow movement of said valve sleeve member to said second position, said second valve spool being in fluid communication with said fluid outlet passage and further adapted for movement to said position to allow movement of said valve sleeve member to said second position when the fluid pressure within said fluid outlet passage reaches a predetermined value, whereby movement of said valve sleeve member to said second position to allow fluid communication between said fluid inlet passage and said fluid relief passage may be effected.

3. A pressure compensated diverter valve as defined in claim 2 wherein said valve member includes means for effecting a pressure drop between said fluid inlet passage and said fluid outlet passage during fluid flow through the diverter valve.

4. A pressure compensated diverter valve as defined in claim 3 wherein said means for effecting a pressure drop between said fluid inlet and fluid outlet passages comprises at least one flow restricting orifice.

5. A pressure compensated diverter valve as defined in claim 2 including annular groove means disposed about the peripheral surface of said valve member to prevent fluid flow between said peripheral surface and the peripheral surface of said chamber.

6. A pressure compensated diverter valve comprising, in combination, a body member having a chamber therein and including fluid inlet, fluid outlet and fluid relief passages communicating with said chamber, first valve spool means comprising a valve member disposed within said chamber and having an outer peripheral configuration substantially identical to that of said chamber, said first valve spool means being adapted for movement between a first position wherein fluid communication between said fluid inlet passage and said fluid relief passage is blocked, and a second position wherein said fluid inlet passage is in

7

fluid communication with said fluid relief passage, said first valve spool means further including a central cavity therein having one end of said cavity defined by a wall means, said wall means including at least one fluid flow orifice therethrough to allow fluid communication between said fluid inlet passage and said fluid outlet passage, said orifice being adapted to effect a pressure drop between said fluid inlet and said fluid outlet passages, second valve spool means disposed within said chamber and adapted for movement between a position wherein it urges said first valve spool toward said first position, and a position to allow movement of said first valve spool to said second position, said second valve spool being in fluid communication with said fluid outlet passage and further adapted for movement to said position to allow movement of said first valve spool to said second position when the fluid pressure within said fluid outlet passage reaches a predetermined value, said first and second valve spool means being disposed in axial relation, spring means to urge said second valve spool means against said first valve spool means to maintain said first valve spool means in said first position until said predetermined pressure value in said fluid outlet passage is reached, and means operatively associated with said second valve spool means to urge said first valve spool means to said first position until the fluid outlet pressure attains a predetermined pressure value whereupon said first valve spool means may move to said second position by virtue of a fluid pressure differential across said orifice in said end of said first valve spool means.

7. A pressure compensated diverter valve comprising, in combination, a valve body member having a chamber therein and including fluid inlet, fluid outlet and fluid relief passages communicating with said chamber, means including a valve member disposed within said chamber and adapted to block fluid flow between said inlet and relief passages, said valve member including a flow orifice therein to allow continual fluid communication between said inlet and outlet passages, said flow orifice serving to produce a pressure drop therethrough which causes said valve member to be urged to a position wherein fluid flow between said inlet and relief passages is effected as fluid flows between said inlet and outlet passages, and means for resiliently urging said valve member to a position wherein fluid flow between said inlet and relief passages is blocked, said last mentioned means being overcome as a result of a pressure differential created by said pressure drop to thereby allow said valve member to effect fluid flow between said inlet and relief passages when the fluid pressure within said outlet passage reaches a predetermined value.

8. A pressure compensated diverter valve as defined in claim 7 including a second valve spool means adapted to urge said valve member to said blocking position, said second valve spool means being movable away from said valve member at a predetermined outlet pressure to allow said valve member to divert flow from said inlet passage to said relief passage.

8

9. A pressure compensated diverter valve as defined in claim 8 wherein said means for resiliently urging said valve member to said flow blocking position is not overcome by the fluid pressure within said outlet passage until said outlet passage fluid pressure reaches a greater value than said predetermined outlet pressure required to move said second valve spool means away from said valve member.

10. A pressure compensated diverter valve as defined in claim 9 wherein said means for resiliently urging said valve member to said flow blocking position comprises a compression spring.

11. A pressure compensated diverter valve comprising a body, a bore in said body, inlet, outlet and pressure relief ports in said body which communicate with said bore, a spool slidably disposed in said bore and actuable between a first position blocking fluid communication between said inlet and relief ports and a second position permitting fluid communication between said inlet and relief ports, means for biasing said spool to said first position with a given force, said means being responsive to fluid pressure so that said biasing force is reduced when fluid pressure in said bore reaches a predetermined value, and means responsive to fluid flow in said bore between said inlet and outlet ports for biasing said spool to said second position with a force which is sufficient to overcome said reduced force biasing said spool to said first position only when said fluid flow reaches a predetermined value.

12. A diverter valve as defined in claim 11 wherein said last mentioned means includes flow orifices in said spool effective to establish a pressure differential thereacross acting to urge said spool to said second position when said fluid flow reaches said predetermined value.

13. A diverter valve as defined in claim 12 wherein said spool includes a wall portion disposed in the fluid flow path between said inlet and outlet ports, said wall portion having said flow orifices therein.

14. A diverter valve as defined in claim 11 wherein said means for biasing said spool toward said first position includes a second valve spool adapted to urge said first spool to said first position and being responsive to fluid pressure within said outlet port for movement to a position reducing the biasing force against said first spool.

References Cited

UNITED STATES PATENTS

704,557	7/1902	Michener	137—514.5
2,436,544	2/1948	Beacham	137—115 XR
2,737,196	3/1956	Eames	137—115 XR
3,140,722	7/1964	Gordon	137—108

ALAN COHAN, Primary Examiner

WILLIAM H. WRIGHT, Assistant Examiner

U.S. Cl. X.R.

137—115, 118