An accumulator piston (10) for an automatic transmission (12). The piston (10) comprises two components, the first and second being cup elements (32 and 36) welded together with their closed ends in abutment relation. The lower cup (32) includes a curled back portion with a radial flange having an axially extending bi-directional oil seal (34) thereon, and spaced apart recesses in the curled back portion to permit oil to flow therein. The upper cup (36) includes a radial flange of reduced diameter compared to the lower cup flange. The flange also has a lip seal (40) thereon. The piston (10) is spring-loaded and moves up and down in a pair of opposed bores (46 and 72) in response to fluid flow on either side to absorb shifting shocks.
FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

<table>
<thead>
<tr>
<th>AL</th>
<th>Albania</th>
<th>ES</th>
<th>Spain</th>
<th>LS</th>
<th>Lesotho</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>Armenia</td>
<td>FI</td>
<td>Finland</td>
<td>LT</td>
<td>Lithuania</td>
</tr>
<tr>
<td>AT</td>
<td>Austria</td>
<td>FR</td>
<td>France</td>
<td>LU</td>
<td>Luxembourg</td>
</tr>
<tr>
<td>AU</td>
<td>Australia</td>
<td>GA</td>
<td>Gabon</td>
<td>LV</td>
<td>Latvia</td>
</tr>
<tr>
<td>AZ</td>
<td>Azerbaijan</td>
<td>GB</td>
<td>United Kingdom</td>
<td>MC</td>
<td>Monaco</td>
</tr>
<tr>
<td>BA</td>
<td>Bosnia and Herzegovina</td>
<td>GE</td>
<td>Georgia</td>
<td>MD</td>
<td>Republic of Moldova</td>
</tr>
<tr>
<td>BB</td>
<td>Barbados</td>
<td>GH</td>
<td>Ghana</td>
<td>MG</td>
<td>Madagascar</td>
</tr>
<tr>
<td>BE</td>
<td>Belgium</td>
<td>GN</td>
<td>Guinea</td>
<td>MK</td>
<td>The former Yugoslav</td>
</tr>
<tr>
<td>BF</td>
<td>Burkina Faso</td>
<td>GR</td>
<td>Greece</td>
<td>ML</td>
<td>Mali</td>
</tr>
<tr>
<td>BG</td>
<td>Bulgaria</td>
<td>HU</td>
<td>Hungary</td>
<td>MN</td>
<td>Mongolia</td>
</tr>
<tr>
<td>BJ</td>
<td>Benin</td>
<td>IE</td>
<td>Ireland</td>
<td>MR</td>
<td>Mauritania</td>
</tr>
<tr>
<td>BR</td>
<td>Brazil</td>
<td>IL</td>
<td>Israel</td>
<td>MW</td>
<td>Malawi</td>
</tr>
<tr>
<td>BY</td>
<td>Belarus</td>
<td>IS</td>
<td>Iceland</td>
<td>MX</td>
<td>Mexico</td>
</tr>
<tr>
<td>CA</td>
<td>Canada</td>
<td>IT</td>
<td>Italy</td>
<td>NE</td>
<td>Niger</td>
</tr>
<tr>
<td>CF</td>
<td>Central African Republic</td>
<td>JP</td>
<td>Japan</td>
<td>NL</td>
<td>Netherlands</td>
</tr>
<tr>
<td>CG</td>
<td>Congo</td>
<td>KE</td>
<td>Kenya</td>
<td>NO</td>
<td>Norway</td>
</tr>
<tr>
<td>CH</td>
<td>Switzerland</td>
<td>KG</td>
<td>Kyrgyzstan</td>
<td>NZ</td>
<td>New Zealand</td>
</tr>
<tr>
<td>CI</td>
<td>Côte d’Ivoire</td>
<td>KP</td>
<td>Democratic People’s Republic of Korea</td>
<td>PL</td>
<td>Poland</td>
</tr>
<tr>
<td>CM</td>
<td>Cameroon</td>
<td>KR</td>
<td>Republic of Korea</td>
<td>PT</td>
<td>Portugal</td>
</tr>
<tr>
<td>CN</td>
<td>China</td>
<td>LC</td>
<td>Saint Lucia</td>
<td>RO</td>
<td>Romania</td>
</tr>
<tr>
<td>CU</td>
<td>Cuba</td>
<td>KZ</td>
<td>Kazakhstan</td>
<td>RU</td>
<td>Russian Federation</td>
</tr>
<tr>
<td>CZ</td>
<td>Czech Republic</td>
<td>LI</td>
<td>Liechtenstein</td>
<td>SD</td>
<td>Sudan</td>
</tr>
<tr>
<td>DE</td>
<td>Germany</td>
<td>LK</td>
<td>Sri Lanka</td>
<td>SE</td>
<td>Sweden</td>
</tr>
<tr>
<td>DK</td>
<td>Denmark</td>
<td>LR</td>
<td>Liberia</td>
<td>SG</td>
<td>Singapore</td>
</tr>
<tr>
<td>EE</td>
<td>Estonia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI</td>
<td>Slovenia</td>
<td>SK</td>
<td>Slovakia</td>
<td>SN</td>
<td>Senegal</td>
</tr>
<tr>
<td>SZ</td>
<td>Swaziland</td>
<td>TG</td>
<td>Togo</td>
<td>TJ</td>
<td>Tajikistan</td>
</tr>
<tr>
<td>TM</td>
<td>Turkmenistan</td>
<td>TR</td>
<td>Turkey</td>
<td>TT</td>
<td>Trinidad and Tobago</td>
</tr>
<tr>
<td>UA</td>
<td>Ukraine</td>
<td>UG</td>
<td>Uganda</td>
<td>US</td>
<td>United States of America</td>
</tr>
<tr>
<td>UZ</td>
<td>Uzbekistan</td>
<td>VN</td>
<td>Viet Nam</td>
<td>YU</td>
<td>Yugoslavia</td>
</tr>
<tr>
<td>ZW</td>
<td>Zimbabwe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IMPROVED ACCUMULATOR PISTON

BACKGROUND OF THE INVENTION

The present invention relates generally to automatic transmissions, and more particularly, to an accumulator piston used therein. Specifically, the invention relates to an improved so-called 1-2 accumulator piston, which is made and assembled into one piece from two pieces, and which includes two seals bonded to the piston. This arrangement is advantageous from the standpoints of simplicity, reliability, and installation in the intended application.

As currently manufactured, one form of the 1-2 accumulator piston includes two O-rings as the seal. By switching to a welded component having two deep-drawn cups separately formed and then butt-welded together, with the seals being bonded on to the stampings or casings, an improved product is made.

Basically, the 1-2 accumulator piston in prior art transmissions has either been an aluminum casting or a plastic piston. In the case of the aluminum casting, two loose lip seals or O-rings were used. In case of the plastic, two loose lip seals or O-rings were also provided. The aluminum approach had the disadvantage of being more expensive, because of the machining required on several surfaces. The aluminum cup, in addition, was heavier and in some cases less accurate. The loose lip seals were not as durable as bonded seals. In addition, the problem of a fit in the bore was presented. A machined aluminum casting with loose O-ring seals had the further disadvantage of galling in the steel or aluminum bore formed in the housing.

In the case of plastic, the strength was questionable as regards the piston. This shortcoming was particularly apparent over the life of the product, which could easily exceed 100,000 miles or perhaps, even two or three times that amount. Prior art plastic cups simply did not have
the potential life expectancy of a more substantive piston. The invention does away with the need of O-ring or other loose lip seals, replacing them with bonded seals having several advantages.

A one-step assembly process is necessary to the design, which includes a major diameter cup and a smaller diameter cup, with the two cups being deep drawn and welded together at the interface. The resulting metal is much stronger than prior art designs, it is lighter, less durable, and less expensive.

In view of the failure of the prior art to develop an accumulator piston of an advantageous type, it is an object of the present invention to provide an approved accumulator piston.

Another object of the present invention is to provide a one-piece component in place components having O-rings or other loose-fitting seals.

Yet another object of the present invention is to provide a bonded accumulator piston and seal unit requiring no additional assembly operations by the end user, that is, the labor force at the automatic transmission assembly point.

Still another object of the invention is to make housekeeping easier for the user, in the sense of taking up less warehouse space with separate components requiring assembly and subsequent fitting.

It is a further object of the invention to provide an element which, in use, will avoid undue pinching of rubber elements. In this connection, a dual molded lip is more durable and less likely to be torn or otherwise damaged in use.

In particular, it is an object of the invention to locate the seals on the part where they will not engage the ports or openings in the bores during the assembly process.

A still further object of the invention is to provide a piston wherein scoring or galling of the running surfaces can be avoided, particularly those where there would be
metal-to-metal contact in the event of misalignment in either aluminum or steel housings. By way of explanation, when a non-bonded O-ring moves in the groove in which it is located, it eventually becomes torn or breaks down. Metal-to-metal contact then occurs. This occurs with every non-bonded O-ring. When there is misalignment, wear is accelerated.

An additional object of the invention is to provide reduced stresses and strains and increased fatigue life over the expected life of the unit.

Yet another object of the invention is to provide a lower cost assembly compared with an aluminum forging or casting.

Still another object of the invention is to provide easier installation than is attainable with constructions containing O-rings.

More specifically, another object is to avoid the presence of O-rings, which, during installation, and thereafter, are more easily cut by the passages in the bores, creating questionable installation reliability.

A further object of the invention is to avoid scuffing and galling of the parts relative to each other.

A still further object of the invention is to do away with scuffing of the bore surface by reason of having rubber-to-metal contact rather than aluminum-to-steel contact in the area of the bores or, in the alternative, with aluminum-to-aluminum to contact in the bore.

The above advantages of the invention are achieved in practice by providing a bonded piston, preferably laser welded and made from two deep draws, with the open sides of the draws being directed oppositely and with each end portion of the piston having its own associated seal bonded thereto.

The exact manner in which the foregoing invention is achieved in practice will become more clearly apparent when reference is made to the following detailed description of the invention set forth by way of example and shown in the
accompanying drawings, in which like reference numbers indicate corresponding parts throughout.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side elevational view, with portions broken away, showing the principal elements of the invention along with an automatic transmission of the invention in which the improved piston is used;

Fig. 2 is a side elevational view, on a greatly enlarged scale, showing the bonded 1-2 accumulator piston in position of use, and showing the sources of hydraulic fluid and the ports served thereby;

Fig. 3 is an exploded perspective view, showing one form of the piston of the invention showing the same before assembly;

Fig. 4 is a view showing the laser-type welding being accomplished so as to join the abutted edges of the piston elements together;

Fig. 5 is a modified form of the invention; and,

Fig. 6 is a further modified view of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

While the invention may comprise several aspects, and may take on several forms in use, several presently preferred embodiments of the invention will be discussed below.

Fig. 1 shows the laser-bonded piston of the invention generally designated 10 to be contained within an automatic transmission generally designated 12. Fig. 1 shows the invention to include a housing for the transmission generally designated 14, a flex plate 16, a torque converter 18, a plurality of gear sets 20, 22, and an output shaft 24. In particular, the 1-2 accumulator piston is disposed in a bore generally designated 26, which includes a downward biased spring 28, an upwardly biased spring 30, and a movable piston operating between the two.

Referring in particular to Fig. 2, the composite piston 10 is shown to include a reduced diameter housing 32
which includes a radial lip seal 34 at the end thereof, and
the spring 28 held captive therein. The second component
36, contains a captive spring 30, shown somewhat compressed
in Fig. 2, and includes a convoluted wall section 38,
having an enlarged diameter, two way seal 40 forming its
dend portion. The piston 36 includes a closed end 42, and
plural scallops 44 or the like, permitting entry of oil for
the purpose of actuating the piston. The bore 46, which is
enlarged to accumulate the larger end of the piston,
includes a snap-ring 48, and a piston support 50, having a
seal on the end portion. The support includes a well 52
and a surrounding ridge 54, which engages the bottom of the
piston in the downwardmost position. The bore 46 includes
a pair of inlet ports, a lower port 56 and an upper port
58. The lower port 56 is serviced by a pressure passage
60, and the second part is serviced by a pressure passage
62. On the opposite side of the bore 46 is an exhaust port
64, serviced by a passage 66 and is connected in use to a
line tap. In use, pressure in the port 56 serves to move
the piston 36 up, while pressure in the port 58 serves to
move the piston 36 down. Finally, an outlet port 68 and a
passage 70 serve the purpose of permitting the oil on the
upper side of the piston to return by venting to a clutch
housing area. The seal 34 is positioned in a counterbore
72 of somewhat reduced diameter in respect to the first
principal bore 46. Preferably, a plug 69 in the end of the
bore serves as a perch for the upper spring 28, and a
contoured opening 71 therein leads to the outlet port 68.
Assembly is aided by the use of a taper 74 where the
principal bore 46 meets a shoulder 70 in the bore.

The hydraulic accumulator is necessary to automatic
transmissions. Accumulators are used in parallel to
cushion the application of servos and hydraulic clutches.
When hydraulic fluid accelerates or changes direction
rapidly such as when pressure is applied through a shift
valve, it is subject to surging. A rapid surge of
hydraulic pressure can cause an "apply" device to vibrate
or to engage harshly. This would cause rough shifts and could conceivably damage the transmission. An accumulator cushions or damps hydraulic pressure surges. This is done by temporarily diverting a part of the fluid in the circuit into a parallel circuit or chamber, in this case having a resiliently movable piston. The diversion allows pressure to increase in the main circuit more gradually (although still in a relatively short time) and provides the desired smooth engagement of the band or clutch with which it is associated in use. In this case, it is the 1-2 shift mechanism.

The 1-2 accumulator thus comprises a pair of back-to-back welded piston halves or the like that are able to move from one position to another in use. To move the piston upward as shown in Fig. 2, the unit operates as described. The overdrive-drive-1 pressure that was blocked at the 1-2 shift valve in first gear is shifted so that the hydraulic pressure flows through the valve to the intermediate clutch, the 1-2 accumulator, and to the overdrive-servo regulator valve.

As a result, the pressure appearing in the oil thus flows through the line and appears at the port 56. A scallop or relief on the underside of the piston permits oil to fill the piston, as well as passing between the seals 42 and 43 and exerting a biasing-apart force on them. This urges the piston in an upward direction, causing flow out the port 58 and the line 62, until the piston reaches the top of its travel. This moves fluid from the region above the piston to a clutch housing area. Whereas there is line pressure in the line 62, the accumulator sees more pressure by reason of filling the entire interior of the piston. In addition, causing the piston to move to its upwardmost position and compresses the spring 28, while relieving the pressure on the spring 30. The port 64 and line 66 are connected to a line tap.

In another situation, an opposite movement of the accumulator piston takes place. In this instance, the line
or higher pressure is seen at line 62 and port 58, while
the port 56 and the line 60 see a diminished pressure.
With this condition, the pressure is greater on the
upwardly facing surfaces (Fig. 2) than the downward facing
surfaces, and the piston compresses the spring 30 and
descends to its low position as shown in Fig. 2.

Referring now to Figs. 3 and 4, a method of making the
unit is shown. Here, the upper section 32 and the lower
section 36 are shown. The deep draw into a cup 32 is made,
following which the lip 34 is bonded to the unit. In
Fig. 3, the bottom surface 42 of the piston 36 is shown, as
is the curl 38 or return upon itself, and the dual lip seal
40. The scallops 42 are also shown in this illustration.
In this instance, the walls of the upper and lower pistons
36, 32 are of the same diameter. Once held in aligned
relation, a laser beam 80 is shown melting the edges of the
piston and securing the two halves together along the
interface 92 shown in the drawings. The laser welder is
the preferred method of welding, using a highly localized
beam and little heat outside that concentrated at the
welding point.

In Fig. 5, an embodiment is shown wherein the enlarged
diameter piston portion 136 contains, in addition to the
convoluted portion 138 and the dual lip seal 140, a
depressed center section generally designated 182. This
section 182 is shown to include a wall section 184 and a
bottom section 186 constituting a further draw in the
steel. The scallop 144 is illustrated as being in a
rounded or out-of-phase position with respect to its
counterpart in the other embodiments.

Shown with the cup 136 is the other piston-forming
unit 132 having a side wall 132 and a bonded seal 134.
This unit also includes a second draw in the portion into
which the nose 186 will protrude. In addition to the
bottom wall 138, the piston includes an offsetting center
wall 140, and a re-entrant portion 142. In addition, an
optional second wall portion 144 is taken from the portion
of metal forming the end wall 146. This form of apparatus is used when the centering between the two units is in question, or when a stronger bond is preferred. A weld at the interface 192 is shown. In use, the piston operates in the same manner as its counterpart shown in Fig. 2. The weld 192 is formed on a smaller diameter than in its counterpart in Fig. 2.

Referring now to Fig. 6, a still further embodiment of the invention is shown. Here, the smaller diameter portion of the piston 232 having the bonded seal 234 is shown to include, at the depth of the principal draw 246, a stepped or second draw 242. This presents a reduced diameter nose portion 242, to be accommodated in a pocket in the upper portion of the piston 236. This pocket is generally designated 243, and is shown to be defined by a side wall 284, and a bottom wall 286, formed in the larger diameter portion of the piston 236. In this case, a somewhat different configuration of scallop 244 is shown as being drawn from the stack that formed the curl 238 in the side wall 236.

The dual lip seal 240 is of the same kind as is shown in the other illustrations, and is formed in the same way. The circumference of the position at which the weld is made, 292 is also somewhat reduced in size, as the opening 243 serves as a pilot diameter for the side wall 246. This insures a close fit between parts and does away with any possible misalignment.

Referring to the material from which the components of the invention are made, the two cups of the invention are preferably made from a steel material. In one respect, the simpler form of the first embodiment is preferred, while the interlocking function may be achieved by the other. The seals are made from a hydrogenated nitrile rubber preferably or may be made from other synthetic elastomers of a suitable type.

It will thus be seen that the present invention provides a new and improved accumulator having a number of
advantages and characteristics including those pointed out and others which are inherent in the invention. Several preferred embodiments of the invention being shown by way of example, it is anticipated that several variations may be made from the preferred form of the invention and that such modifications and changes may be made without departing from the spirit of the invention and the scope of the appended claims.
1. An accumulator piston for an automatic transmission, said accumulator piston being formed in one piece from two components, said first component being a cup element having a bottom wall, a side wall, and a radially outwardly extending flange, and bonded to said flange, a sealing lip having a gradually enlarging diameter, the second component also being a cup element having a bottom wall, a side wall, a skirt of enlarged diameter folded over so as to lie radially outwardly of said cup side wall, and a radial flange extending outwardly from said side wall, said folded over portion of said cup element having at least one re-entrant portion in said skirt, and, bonded to said flange, an elastomeric seal body comprising a pair of sealing lips each extending radially outwardly from said flange and axially outwardly in opposite directions from a point of minimal outer radial diameter, said cup elements being fastened together with their closed ends in abutting relationship so as to form said two-piece accumulator piston.

2. An accumulator piston as defined in claim 1, wherein said two cup elements are formed from a steel material by drawing.

3. An accumulator piston as defined in claim 1, wherein all of said sealing lips are formed from a carboxylated nitrile material.

4. An accumulator piston as defined in claim 1, wherein said cup elements are fastened together by welding.

5. An accumulator piston as defined in claim 1, wherein said piston elements are fastened together by laser welding.

6. An accumulator piston as defined in claim 1, wherein said cup elements further include auxiliary...
formations nesting with one another to assure concentricity.

7. An accumulator piston as defined in claim 6, wherein said elements are fastened together by welding and said contour of said cups are such that said weld is formed on a smaller diameter than the major diameter of said piston element.

8. An accumulator piston as defined in claim 6, wherein said nesting relation is formed by an outwardly extending second draw on said first cup and inwardly extending draw on said second cup.

9. An accumulator piston as defined in claim 6, wherein said nesting relation is formed by an outwardly extending second draw on said second cup and inwardly extending draw on said first cup.

10. An automatic transmission and accumulator piston assembly comprising, in combination, an automatic transmission housing having a first bore, an opening in said first bore forming a first outlet port, a second, slightly enlarged bore coaxially aligned with said first bore and having therein at least first and second inlet ports and a third port communicating with a clutch housing, a circumferential groove, and a further enlarged diameter portion coaxially aligned with said first and second bores, a snap-ring located in said groove, a piston supporting member held in place by said snap ring, said piston support member including a radial mounting flange and a peripheral lip seal bonded thereto, and a formation for receiving a compression spring, a first compression spring supported at one end by said formation, and a composite accumulator piston element disposed in said first and second bores, said piston including a first cup body, at least one opening in said cup body side wall, a skirt lying at least
19 partially radially outside said cup body and axially
20 overlying said cup body, a radial flange forming the
21 outermost part of said skirt, a double lip seal having
22 portions extending axially from said skirt flange in both
23 axial directions, and into contact with the wall of said
24 second bore, with said spring having its other end received
25 at least partially within said first cup body, and, located
26 at least partially within said first bore, a second piston
27 part comprising a second cup and a radial flange portion
28 with a lip seal element bonded to the outermost portion
29 thereof and extending into contact with said first bore,
30 said first and second piston cups being arranged with their
31 closed ends together and being fastened to each other along
32 at least a major part of their circumference, and a second
33 piston spring disposed in said first bore between the first
34 cup of said second piston and the end of said bore,
35 whereby, in use, said piston is alternately driven up and
36 down in said bores by pressure appearing at said first and
37 second ports.

11. An automatic transmission and accumulator piston
assembly as defined in claim 10, wherein said piston cups
are made from a drawn steel material.

12. An automatic transmission and accumulator piston
assembly as defined in claim 10, wherein said cups are
drawn from a thin steel material and are fastened together
by welding.

13. An automatic transmission and accumulator piston
assembly as defined in claim 10, wherein said cups are
drawn from a thin steel material and are fastened together
by laser welding.

14. An automatic transmission and accumulator piston
assembly as defined in claim 10, wherein said first and
second piston cups further include respectively, formations
extending axially inwardly and outwardly in nested
relation, thereby insuring that said piston cups, in their
assembled relation, abut each other.

15. An automatic transmission and accumulator piston
assembly as defined in claim 14, wherein said cups are
welded together about a smaller diameter than the diameter
of said piston cups.

16. An automatic transmission and accumulator piston
assembly as defined in claim 14, wherein said nested
relation is formed by an outwardly extending draw on said
first cup and an inwardly extending draw on said second
cup, said two cups being fastened to each other by welding.

17. An automatic transmission and accumulator piston
assembly as defined in claim 14, wherein said nested
relation is formed by an inwardly extending draw on said
first cup and an outwardly extending draw on said second
cup, said two cups being fastened to each other by welding.
### INTERNATIONAL SEARCH REPORT

**PCT/US98/23165**

#### A. CLASSIFICATION OF SUBJECT MATTER

<table>
<thead>
<tr>
<th>IPC(6)</th>
<th>F16J 9/00; F16H 57/02</th>
</tr>
</thead>
<tbody>
<tr>
<td>US CL</td>
<td>74/606R; 92/240, 241, 107, 85 A, 85 B, 18, 183</td>
</tr>
</tbody>
</table>

According to International Patent Classification (IPC) or to both national classification and IPC

#### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

| U.S. | 74/606R; 92/240, 241, 107, 85 A, 85 B, 18, 183 |

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

#### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 5,492,053 A (STONEHILL) 20 February 1996, col. 4, lines 41-59.</td>
<td>1-17</td>
</tr>
<tr>
<td>A</td>
<td>US 5,014,599 A (KOCSIS et al.) 14 May 1991, see Figs. 1-7.</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>US 4,987,796 A (von KALER et al.) 29 January 1991, see cup 50.</td>
<td>1</td>
</tr>
<tr>
<td>Y</td>
<td>US 4,635,778 A (LEDERMAN) 13 January 1987, col. 1, line 67 et seq.</td>
<td>1-17</td>
</tr>
<tr>
<td>Y</td>
<td>US 3,814,226 A (WHITE) 04 June 1974, col. 3, line 6 et seq.</td>
<td>1-17</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C. See patent family annex.

| * | Special categories of cited documents |
| **A** | document defining the general state of the art which is not considered to be of particular relevance |
| **E** | earlier document published on or after the international filing date |
| **L** | document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) |
| **O** | document referring to an oral disclosure, use, exhibition or other means |
| **P** | document published prior to the international filing date but later than the priority date claimed |
| **T** | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
| **X** | document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| **Y** | document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| **A** | document member of the same patent family |

Date of the actual completion of the international search: 19 FEBRUARY 1999

Date of mailing of the international search report: 11 MAR 1999

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks

Box PCT

Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized office: VINHT T. SOUR

Telephone No. (703) 308-3221

Form PCT/ISA/210 (second sheet) (July 1992)*