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(54) Title: A PNEUMATIC IMPACT MECHANISM

(57) Abstract: The invention relates to a pneumatic impact mechanism of the kind used in a rock drill. A reciprocating piston (4, 44) is configured: to place a drive chamber (5, 41) in fluid communication with an inlet (23; 51) towards an end of a return stroke and to place the return chamber (6; 42) in fluid communication with at least one exhaust outlet (34; 35; 52) for the piston (4; 44) to commence a drive stroke; and, to place the return chamber (6; 42) in fluid communication with the inlet (23; 51) towards an end of the drive stroke and to place the drive chamber (5; 41) in fluid communication with the at least one exhaust outlet (34; 35; 52) for the piston (4; 44) to commence a return stroke. The switching of the flow paths based on the relative position of the piston (4; 44) serves to alternately generate drive and return strokes. In one embodiment, the piston (4) has a longitudinal air distribution pocket (24) located over the inlet that communicates with the drive chamber (5) and return chamber (6) respectively through the first bridging port (32) and a second bridging port (33) in the wall of the housing, with the piston (4) respectively uncovering a first exhaust outlet (34) from the drive chamber (5) and a second exhaust outlet (35) from the return chamber (6). In another embodiment, a first radial port (45) in the piston (44) feeds a first bypass passage (46) along the length of the piston (44) which opens to the drive chamber (41) and a second radial port (48) feeds a second bypass passage (48) which opens to the return chamber (42). The radial ports (45, 48) are alternately placed in communication with the inlet (51) and a single exhaust outlet (52), located between the inlet and return chamber, is either placed in communication with the first radial port (45) or uncovered by the return stroke of the piston (44) to vent the return chamber (42).

![Diagram](image-url)
A PNEUMATIC IMPACT MECHANISM

FIELD OF THE INVENTION

The invention relates to a rock drill and particularly an impact (or percussion) mechanism for a rock drill of the kind operated by pressurised air. These rock drills are extensively used in underground mines for, amongst others, drilling blast holes and rock anchor holes. The impact mechanism may alternatively be employed in apparatus for rock or concrete breaking.

BACKGROUND TO THE INVENTION

Since the late 1800's rock drills have remained very much the same in construction and because they worked (relatively) well, there was never a need for major improvements to their functionality or construction. In our day and age, however, the need for a smaller carbon footprint and more efficient utilisation of available energy, have become important factors.

The impact mechanisms for these pneumatic rock drills invariably operate on a valve controlled drill cycle - the valve directs the supply air to working chambers on either side of a piston to achieve reciprocation.

The problems with the inclusion of a valve into the system are many fold. The most obvious is that the production of a valve box, valve and valve plug (as common
components of the valve) increase the overall cost of manufacturing and material used in the machine and also make the (frequently) hand held machine heavier for the operator to use.

The inclusion of a valve also (in those constructions with which the applicant is familiar) increases the air consumption (decreasing efficiency of the machine) and increases the noise level of the machine as well. Firstly, a valve which reciprocates out of sync with the reciprocation of the hammer piston and is fed from pressurized air and uses precious energy for its own motivation. Apart from the usage of air, there is also a constant intentional leak into the drive chamber.

The misuse of energy and compressed air, is not only from the functioning of the valve as mentioned, but comes about from the way the valve is intended to operate. During the stroke cycle, the valve is always open to feed either the drive chamber or return chamber, so there is airflow through the valve almost throughout the cycle time (there may be a slight "dead" no flow overlap spot during the stroke of the valve as it is momentary engaged in both seats at the same time when it has almost exited the one seat and has already entered the other).

It would appear that (at least in some cases) the chambers are (purposely) over-energized due to the way the valve functions. There is virtually no percentage of non-flow during the cycle, resulting in excess air filling the chambers resulting in more noise from the unspent higher pressure exhaust air exploding into the low atmospheric pressure of the surrounding air.

Added to the inefficient air consumption is that the return chamber is fed via tubular ports which extend from the valve at the one side of the cylinder (or impact mechanism housing within which the piston reciprocates) to almost the extreme other end of the cylinder and these tubular ports are filled and emptied from compressed air with each cycle. Also the valve itself has a certain decibel noise factor.
One example of such a pneumatic drill is manufactured by Seco. Various alternative embodiments are disclosed in the specification of International application number PCT/IB2004/050254 filed by Sulzer South Africa Limited.

5 **OBJECT OF THE INVENTION**

It is an object of the present invention is to improve the functionality and simplify the construction of pneumatic rock drills and particularly the impact mechanisms which are currently reliant on valves for the controlled supply of the working fluid to a drive and return chamber.

**SUMMARY OF THE INVENTION**

In accordance with the invention there is provided a pneumatic impact mechanism comprising:

- a piston reciprocable between a drive chamber and a return chamber in a housing;
- a supply air inlet located through the housing between the drive chamber and return chamber; and
- at least one exhaust outlet from the housing;

with the piston configured

- to place the drive chamber in fluid communication with the inlet as the piston moves towards an end of a return stroke and to place the return chamber in fluid communication with the at least one exhaust outlet for the piston to commence a drive stroke; and
- to place the return chamber in fluid communication with the inlet as the piston moves towards an end of a drive stroke and to place the drive chamber in fluid communication with the at least one exhaust outlet for the piston to commence a return stroke;

30 to alternately generate drive and return strokes.

In accordance with one aspect of the invention there is provided
- a first bridging port and a second bridging port in a wall of the housing, longitudinally spaced apart from and to either side of the inlet; 
- with the at least one exhaust outlet radially spaced apart from the inlet; and
- the piston having a longitudinal air distribution pocket located over the inlet that communicates with the drive chamber and return chamber respectively through the first bridging port and a second bridging port and the piston respectively uncovering a first exhaust outlet from the drive chamber and a second exhaust outlet from the return chamber.

A further feature of the invention provides for the pocket to be located on the piston between a first radial shoulder and a second shoulder, the first bridging port provided to allow air from the pocket past the first shoulder to the drive chamber, the second bridging port provided to allow air from the pocket past the second shoulder to the return chamber, and at least one exhaust outlet from the housing to be located between the first and second bridging ports and radially spaced apart from the inlet for isolation from the pocket.

The invention further provides for a drive chamber exhaust outlet to be provided between and radially spaced apart from the first bridging port and inlet; and for a return chamber exhaust outlet to preferably be provided between and radially spaced apart from the second bridging port and inlet.

The invention still further provides for the first shoulder to be adjacent a drive chamber edge of the piston and the second shoulder adjacent a return chamber edge of the piston, with a drive chamber exhaust outlet and a return chamber exhaust outlet longitudinally spaced apart from each other provided to exhaust the drive chamber and return chamber when the drive chamber edge and return chamber edge respectively move past the drive and return chamber exhaust outlets.

Further features of the invention provide for the inlet and the first and second bridging ports to be substantially in line; for drive and return chamber exhaust outlets to be substantially in line; and for there to be a diametrically oppositely located one
of each of the inlet, first and second bridging ports and drive and return chamber exhaust outlets.

Further features of the invention provide for the piston to be rotatable on a rifle bar and splined to a chuck with a series of radially spaced apart air distribution pockets, which maintain the inlet in isolation from the at least one exhaust outlet.

The term "isolated" or "in isolation" as used in this specification will be within the meaning of what is required (within reasonable functional limits) to establish a working pressure differential between supply and exhaust pressure in a pneumatic mechanism of the kind to which the invention relates, as will be understood by a person skilled in the art.

In accordance with another aspect of the invention there is provided

- a first radial port which feeds a first bypass passage along the length of the piston which opens in a first face of the piston located in the drive chamber; and
- a second radial port which feeds a second bypass passage along the length of the piston which opens in a second face of the piston located in the return chamber;
- the first and second radial ports longitudinally spaced apart with the first radial port between the second radial port and the second face and the second radial port between the first radial port and the first face;
- the first and second radial ports arranged to alternately be located in fluid communication with the inlet; and
- a land on the piston between first and second radial ports shutting off air supply as the first and second radial ports transition between inlet communicating positions.

The invention further provides for an exhaust outlet to be provided between the inlet and the return chamber, the first radial port to be locatable over the exhaust outlet before the piston commences on the return stroke and the second face of the piston
to move past the exhaust outlet to vent the return chamber before the piston commences on the drive stroke.

The invention extends to a rock drill with an impact mechanism as defined above.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the invention will become more apparent from the following description of one embodiment, made by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view of the rock drill taken along a line which shows working fluid supply passages to a return chamber and a drive chamber;

Figure 2 is a cross-sectional view of a rock drill impact mechanism taken along a line (radially spaced apart from the cross-section line of Figure 1) which shows an exhaust passage from the return chamber and the drive chamber;

Figure 3 is a cross-sectional end view of a piston of the rock drill in Figures 1 and 2 (in a schematic depiction of a piston housing with ports and outlets); and

Figure 4 is a cross-sectional view of an alternative embodiment of a rock drill.

DETAILED DESCRIPTION OF THE INVENTION

A preferred assembly of a valve-less pneumatic impact mechanism in accordance with the invention is illustrated in relation to a rock drill 1 in Figures 1 to 3. The rock drill 1 includes a cylindrical impact mechanism housing 3 with a piston 4 provided therein for reciprocation between a drive chamber 5 and a return chamber 6. A back head 7 is secured at one end of the housing 3 and a front head 8 at the other end.

The front head 8 supports a chuck 9 fitted with a hexagonal bore insert 10 (to engage around a drill steel with a hexagonal profile) and fixed to a chuck nut 11 which is internally splined and slidably located on a correspondingly splined front
portion 12.1 of a piston stem 12, which extends forwardly (through the centre of the return chamber 6) from a piston head 13 (located between the drive 5 and return 6 chambers). The piston 4 and chuck 9 are rotationally coupled through the splined engagement of these components.

A collar 14 providing a guide which sealingly engages around a rear portion 12.2 of the piston stem 12 is fitted between the housing 3 and front head 8. (The collar 14 also provides a front end wall of the return chamber 6.) The components of a drill steel rotation mechanism in the front head 8 are not directly relevant to the invention and schematically/partially illustrated in or absent from Figures 1 and 2 but will be understood by a person of suitable skill and familiar with such components which are well known. The back head 7 is secured over a ratchet ring 15 and a divider 16 (providing a rear end wall of the drive chamber 5). The ratchet ring 15 supports a helically splined rifle bar 17 allowing rotation of this component in one direction. The rifle bar 17 fits into a correspondingly splined rifle nut 18 fixed into a bore of the piston 4.

Referring to Figure 1, a compressed air line (not shown) is connected to feed a collection cavity 19 in the back head 7. The air enters into passage 20 and travels through an annular recess 16.1 past the divider 16 into an opening 21 that feeds into a supply channel 22 along the housing 3 to an air supply inlet 23 located between the drive chamber 5 and return chamber 6.

The inlet 23 is positioned over a longitudinal radial cut-out providing a distribution pocket 24 in the piston 4. The pocket 24 is located between a first radial (dividing) shoulder 25 and a second radial (dividing) shoulder 26 adjacent opposite sides of the piston head 13.

First and second outer edges 27 and 28 of the piston head 13, adjacent the shoulders 25 and 26, correspond to faces of the piston head 13 providing working surfaces 29 and 30 and which respectively provide (moving) ends of the drive 5 and return 6 chambers defined by the piston 4.
The drive chamber working surface 29 includes the area in the bottom of the piston head cavity 31 and on the back of the rifle nut 18. The return chamber working surface 30 is provided by the annular face of the head 13 around the piston stem 12.

A first bridging port 31 is provided adjacent the drive chamber 5 which is aligned with and longitudinally spaced apart from the inlet 23 and a second bridging port 32 is similarly provided adjacent the return chamber 6.

A pair of longitudinally spaced apart exhaust outlets from the housing 3, one 34 for the drive chamber 5 and the other 35 for the return chamber 6, are located between the first 32 and second 33 bridging ports and radially spaced apart from the inlet 23 (and thus also the bridging ports 32 and 33) for isolation from the live air supply path (as herein described).

The exhaust passages from the housing 3 are shown in the cross-section of Figure 2 with the position of the drive chamber exhaust outlet 34 and return chamber exhaust outlet 35 indicated by the two overlying ovals in Figure 1. The position of the opening 20, bridging ports 32 and 33 and the inlet 23 are similarly indicated in the cross-section of Figure 2.

With the piston 4 in the position shown in Figure 1, the pocket 24 connects the inlet 23 to the second bridging port 33 and fills the bottom or return chamber 6 with live compressed air. The compressed air acts on surface area 30 and pushes the piston 4 towards the back head side. Supply of live air to the return chamber 6 is shut-off when the second shoulder 26 moves out of alignment with the second bridging port 33. The compressed air continues to expand as the piston 4 travel on its return stroke until the return chamber 6 is exhausted when the edge 28 of the piston head 13 passes the exhaust outlet 35 placing the return chamber 6 in communication with channel 36 which extends along the housing 3 and is open to atmosphere.

The piston 4 continues travelling under its own inertia until pocket 24 passes the first bridging port 32 (creating a passage or supply path around the first shoulder 25). The bridging port 32 thus bridges over the sealing part of the piston head 13 and connects the live air from the inlet 23 to compress the top or drive chamber 5. The
compression acts on working surface 29 of the piston 4 and causes the piston 4 to turn around and accelerate on its drive stroke towards striking the drill steel.

The piston thus places the drive chamber in fluid communication with the inlet (via bridging port 32) as the piston moves towards an end of a return stroke and places the return chamber in fluid communication with its exhaust outlet for the piston to commence a drive stroke. The return chamber is similarly connected with the inlet (via bridging port 33) as the piston moves towards an end of a drive stroke (or is in a corresponding position as shown in Figure 1) the drive chamber connected to its exhaust outlet for the piston to commence a return stroke.

The cycling of the piston 4 (which is fixed to the rifle nut 18) on the rifle bar 17 connected to the ratchet ring 15 causes stepwise rotation that is imparted to a chuck 9 (which is fixed to the chuck nut 11). This rotation is in turn transferred to a drill steel to rotate in the normal way which is known for these pneumatic rock drills.

As shown in the drawings, the inlet 23 and the first 32 and second 33 bridging ports are longitudinally aligned, as are the drive and return chamber exhaust outlets 34 and 35. These functional orifices are respectively mirrored to provide pairs, with each one of a pair located on opposite sides of the housing. The supply orifices and exhaust orifices are radially spaced apart by 90 degrees to provide a symmetrical arrangement about the cylinder of the housing.

Figure 3 provides a schematic end view of the housing 3 which shows the radial (spaced apart) arrangement of the bridging ports 32 and 33 relative to and isolated from the exhaust outlets 34 and 35 (but does indicate the longitudinal spacing of these orifices, which can be seen in Figures 1 and 2).

The cross-section of the piston 4 in Figure 3 shows more clearly longitudinal pockets 24 of which there are six, radially spaced apart around the piston head 13. The spacing between each adjacent pair of pockets 24 provides that, as the piston 4 of this embodiment rotates, there is always at least one pocket 24 that is radially aligned for communication with the bridging ports 32 and 33 and/or inlet 23. As a pocket 24 transitions across these openings an adjacent (following) pocket 24 is
brought into operational fluid communication before the previously operational pocket 24 moves past and is shut-off.

The way in which a hammer piston acts as its own valve is by the motion of the piston past porting or cut-outs and connecting such porting or cut-outs via grooves, slots or ports, respectively to the drive and return chambers. When the piston moves towards the bottom position, it connects compressed air into the bottom/return chamber and likewise, when it moves towards the top/drive chamber, it opens and allows compressed air into the top/drive chamber.

The isolation of the respective pockets 24 (save for where adjacent pockets overlap the bridging ports and/or inlet) serves to functionally separate the exhaust outlets (and associated ambient pressure) which are only brought into operation when longitudinal displacement of the reciprocating piston respectively uncovers these outlets 34 and 35 towards the end of its drive and return strokes.

The arrangement provides for switching of a distributed air supply to and exhaust from the drive and return chambers which is dependent on the longitudinal position of the piston in the housing. The radially spaced apart pockets on the piston head are thus configured to maintain the inlet/supply orifices in isolation from the exhaust orifices during reciprocation (which is in this embodiment accompanied by axial rotation) of the piston as it cycles.

There is a sizeable distance, which the piston travels during its stroke, where the pocket 24 is not connected to (or in fluid communication with) either of the drive 5 and return 6 chambers and the arrangement therefore achieves (substantially) zero airflow for that portion of travel in between the chambers. Since this distance is flexible it is up to the designer of a specific machine to calculate the duration of how long a bridging port must stay open to fill a chamber with the correct volume of compressed air that will be fully utilized thereby minimising the air consumption and minimising the noise pollution.

The rock drill of the invention overcomes the problems referred to in the "background of the invention" above by omitting the entire valve and valve gear from the rock drill
and the reciprocating hammer piston becomes its own valve. By eliminating the valve arrangement, automatically the machine becomes lighter, cheaper and simpler to manufacture.

In another embodiment of the invention, which is illustrated in Figure 4, the use of a valve to switch air between drive 41 and return 42 chambers is avoided through an alternatively configured piston 44 having: a first radial port 45 which feeds a first bypass passage 46 that extends along the piston 44 to open in a first face 47 located in the drive chamber 41; and a second radial port 48 which feeds a second bypass passage 49 similarly provided but open to an opposite, second face 50 located in the return chamber 42.

The first 45 and second 48 radial ports are longitudinally spaced apart from each other with the first radial port 45 located between the second (return chamber) radial port 48 and the second (return chamber) face 50 and the second radial port 48 between the first (drive chamber) radial port 45 and the first (drive chamber) face 47. A supply air inlet 51 is located through the housing 43 between the drive chamber 41 and return chamber 42. An exhaust outlet 52 is provided through the housing 43 between the inlet 51 and the return chamber 42.

The radial ports 45 and 48 on the piston 44 are provided: to place the drive chamber 41 in fluid communication with the inlet 51 as the piston 44 moves towards an end of a return stroke and to place the return chamber 42 in fluid communication with the exhaust outlet 52 for the piston 44 to commence a drive stroke; and to place the return chamber 42 in fluid communication with the inlet 51 as the piston 44 moves towards an end of a drive stroke and to place the drive chamber 41 in fluid communication with the exhaust outlet 52 for the piston 44 to commence a return stroke. The arrangement serves to alternately generate drive and return strokes and thus the reciprocation of the piston in the impact mechanism.

The first 45 and second 48 radial ports are thus arranged to alternately be located in fluid communication with the inlet 51. A land 53 on the piston 44 between first 45 and
second 48 radial ports shuts off (or isolates) air supply as the first 45 and second 48 radial ports transition between inlet 51 communicating positions.

The two radial ports 45 and 48 (for the drive and return chamber, respectively) are, more specifically, provided as annular recesses formed around and into the piston. The bypass passage 46 or 49 of one recess 45 or 48 will extend into the piston body to a depth at which it can cross or pass beneath the other recess 45 or 48 within the piston body. There may also be more than one such bypass passage from each recess to its connected working face 47 or 50 and the passages of the respective recesses will be radially spaced apart (or offset) from each other in the piston body.

The first radial port 45 also serves to vent the drive chamber 41 when the piston moves forward, towards the end of the drive stroke - the radial port is placed in communication with the exhaust outlet 52. Venting of the return chamber 42 takes place towards the end of the return stroke as the second face 50 of the piston 44 moves past the exhaust outlet 52, which once uncovered places the return chamber in communication with the atmosphere.

The inlet 51 and exhaust outlet 52 are positioned to respectively connect the drive chamber 41 and return chamber 42 to the air supply and to atmosphere as required for the drill cycle of the reciprocating piston 44. The longitudinal size of the inlet 51 and exhaust outlet 52 together with that of the radial ports (or recesses) 45 and 48 will determine the extent of the fluid communication along a given portion of the piston's travel within the housing 42.

While the specific application of the invention to a rock drill has been illustrated and described, the use of the impact mechanism in rock/concrete breaking equipment will also be appreciated.

A person skilled in the art will appreciate that a number of variations may be made to the features of the impact mechanism described without departing from the scope of the present invention.
CLAIMS

1. A pneumatic impact mechanism comprising:
   a piston reciprocable between a drive chamber and a return chamber in a housing;
   a supply air inlet located through the housing between the drive chamber and return chamber; and
   at least one exhaust outlet from the housing;
   with the piston configured
   - to place the drive chamber in fluid communication with the inlet as the piston moves towards an end of a return stroke and to place the return chamber in fluid communication with the at least one exhaust outlet for the piston to commence a drive stroke; and
   - to place the return chamber in fluid communication with the inlet as the piston moves towards an end of a drive stroke and to place the drive chamber in fluid communication with the at least one exhaust outlet for the piston to commence a return stroke;
   to alternately generate drive and return strokes.

2. An impact mechanism as claimed in claim 1 which includes
   - a first bridging port and a second bridging port in a wall of the housing, longitudinally spaced apart from and to either side of the inlet;
   - with the at least one exhaust outlet radially spaced apart from the inlet; and
   - the piston having a longitudinal air distribution pocket located over the inlet that communicates with the drive chamber and return chamber respectively through the first bridging port and a second bridging port and the piston respectively uncovering a first exhaust outlet from the drive chamber and a second exhaust outlet from the return chamber.

3. An impact mechanism as claimed in claim 2 in which the pocket is located on the piston between a first radial shoulder and a second shoulder, the first bridging port is provided to allow air from the pocket past the first
shoulder to the drive chamber, the second bridging port is provided to allow air from the pocket past the second shoulder to the return chamber, and at least one exhaust outlet from the housing is located between the first and second bridging ports and radially spaced apart from the inlet for isolation from the pocket.

4. An impact mechanism as claimed in claim 3 in which a drive chamber exhaust outlet is provided between and radially spaced apart from the first bridging port and inlet.

5. An impact mechanism as claimed in claim 4 in which a return chamber exhaust outlet is provided between and radially spaced apart from the second bridging port and inlet.

6. An impact mechanism as claimed in claim 3 in which the first shoulder is adjacent a drive chamber edge of the piston and the second shoulder adjacent a return chamber edge of the piston, with a drive chamber exhaust outlet and a return chamber exhaust outlet longitudinally spaced apart from each other provided to exhaust the drive chamber and return chamber when the drive chamber edge and return chamber edge respectively move past the drive and return chamber exhaust outlets.

7. An impact mechanism as claimed in claim 1 in which the inlet and the first and second bridging ports are substantially in line and the drive and return chamber exhaust outlets are substantially in line.

8. An impact mechanism as claimed in claim 8 for there to be a diametrically oppositely located in the housing one of each of the inlet, first and second bridging ports and drive and return chamber exhaust outlets.

9. An impact mechanism as claimed in claim 2 in which the piston is rotatable on a rifle bar and splined to a chuck with a series of radially spaced apart air distribution pockets, which maintain the inlet in isolation from the at least one exhaust outlet.
10. An impact mechanism as claimed in claim 1 which includes
   - a first radial port that feeds a first bypass passage along the length of
     the piston which opens in a first face of the piston located in the drive
     chamber; and
   - a second radial port that feeds a second bypass passage along the
     length of the piston which opens in a second face of the piston located
     in the return chamber;
   - the first and second radial ports longitudinally spaced apart with the
     first radial port between the second radial port and the second face and
     the second radial port between the first radial port and the first face;
   - the first and second radial ports arranged to alternately be located in
     fluid communication with the inlet; and
   - a land on the piston between first and second radial ports shutting off
     air supply as the first and second radial ports transition between inlet
     communicating positions.

11. An impact mechanism as claimed in claim 10 in which an exhaust outlet is
    provided between the inlet and the return chamber, the first radial port is
    locatable over the exhaust outlet before the piston commences on the
    return stroke and the second face of the piston moves past the exhaust
    outlet to vent the return chamber before the piston commences on the
    drive stroke.
### A. CLASSIFICATION OF SUBJECT MATTER

**IPC: B25D 9/14 (2006.01)**

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)

B25D 9/00, 9/14, 9/16, 17/00

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)

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### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 1940388 A (CALLAHAN OSCAR L) 19 December 1933 (19.12.1933) Fig. 1 - 8; page 1, line 63 - page 2, line 85</td>
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Further documents are listed in the continuation of Box C.

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