Title: ARRANGEMENT AND CONTROL OF A CRUSHING PLANT

Abstract: A crushing plant (1) has a crusher (9) and a drive unit (2) which drives the crusher (9). The drive unit (2) is arranged to drive a coupling (5), which transmits power to the crusher (9) via an output shaft (6) from the coupling (5). The crushing plant (1) also has a measuring device (12, 14, 16) which is arranged to determine the torque which the output shaft (6) transmits to the crusher (9). The operation of the crushing plant (1) is monitored by the determination of this torque, with the help of the measuring device (12, 14, 16).
Arrangement and control of a crushing plant

Field of the Invention

The present invention concerns a crushing plant, which comprises a crusher and a drive unit driving the crusher. The invention also concerns a method of monitoring the operation of a crushing plant which comprises a crusher and a drive unit driving the crusher.

Background Art

During normal operation, crushing plants are subjected to varying loads. A crusher, for example a stone crusher, incorporated in such a crushing plant is subjected to considerable variations in load, caused by varying hardness of the material which is to be crushed, varying size of the material and varying quantity of material fed into the crusher. These variations affect the ability of the crusher to crush the material optimally, i.e. to produce the greatest possible amount of crushed material per unit of time with as even a size distribution as possible.

Some kind of control system is often used to increase the effectiveness of the crusher. An example of such a control system is ASR Plus™, which is marketed by Svedala-Arbrå AB, SE, and which is described in EP 0 623 054. This control system is suitable for the control of gyratory crushers, for example, and has as input signals both the pressure and position of the crusher's crushing shaft and also a signal from a converter which measures the current consumption of a motor which drives the crusher. When the load on the crusher varies, the crusher’s crushing shaft is adjusted vertically, thus adjusting the crusher’s crushing setting, in such a way that the crusher continuously
gives the greatest possible production of crushed material while the size distribution is permitted to vary slightly. However, in a case where the drive motor is not an electric motor or is an electric motor which, in addition to the crusher also drives some other device, the control system cannot obtain sufficient information to be able to control the crusher.

US 5 803 376 describes a method of controlling a mobile crusher. The crusher is driven by an hydraulic motor and the motor’s hydraulic fluid pressure and flow rate are measured. The measured values can then give a measure of the power which the hydraulic motor develops. It is also suggested that the rpm of the output shaft of the hydraulic motor is measured. This method has the disadvantage that measurement of the load on the crusher is impossible if the motor is of a type other than hydraulic, or if the hydraulic motor also drives some other component in addition to the crusher.

US 5 833 150 describes a method of controlling a mobile crusher which is driven by an hydraulic pump. The hydraulic pump pumps hydraulic fluid to a number of hydraulic motors, one of which drives the crusher, one drives a feeding system, one drives a discharging system, etc. A tachometer measures the rpm of the crusher and transmits a signal to a control system. However, the crusher’s rpm does not give reliable information on the load on the crusher. The crusher’s rpm will thus vary when the crusher is being started or stopped and during variations in the performance of the hydraulic motor which drives the crusher, even though such rpm variations are not caused by variations in the load on the crusher.

Summary of the Invention
The object of the present invention is therefore to provide a crushing plant in which a drive unit of arbitrary type can be used and which has a device for the
reliable measurement of the load on a crusher, no matter what type of drive unit is used.

This object is achieved with the help of a crushing plant which comprises a crusher and a drive unit driving the crusher and which is characterized by the drive unit being arranged to drive a coupling which transmits power to the crusher via the output shaft of the coupling, and by the crushing plant incorporating a measuring device which is arranged to determine the torque which the output shaft transmits to the crusher. Since the torque is determined on the output side of the coupling it is possible to arrange a drive unit of arbitrary type but still determine a reliable value for the torque. This means that the crushing plant can easily be adapted to varying conditions regarding for example the supply of different fuels. The drive unit can also drive additional devices through a gearbox which is placed between the drive unit and the coupling whilst still permitting the determination of the power which is transmitted to the crusher itself.

Preferably, the drive unit is selected from a group which consists of internal combustion engines and hydraulic motors. Internal combustion engines have the advantage that they are independent of a mains electricity supply. It is thus possible to use the crushing plant in places where there is no access to a mains electricity supply. Particularly suitable as a drive unit is a diesel engine. Diesel engines have several advantages: the fuel is relatively inexpensive and easy to handle and the engines are robust and provide a high torque even at a relatively low, constant rpm.

The coupling is preferably an hydraulic slipping coupling. A major advantage of a slipping hydraulic coupling is that it slips if the crusher stalls, so that the input shaft to the coupling can continue to rotate even though the crusher and the coupling's output shaft are stationary. In this way, excessive loads and damage
to the transmissions and drive units are avoided. It is also an advantage during starting and stopping that the coupling can slip. The flow of hydraulic fluid to the coupling can for example temporarily be cut off so that the drive unit can be accelerated up to full speed before the crusher is allowed to speed up at a smooth rate. The slipping coupling also has major advantages during normal operation since transmission shocks and vibrations from the drive unit are not transmitted to the crusher. In the same manner, vibrations from the crusher are not transmitted to the gearbox and the drive unit.

According to a preferred embodiment, the measuring device is arranged to measure a first rpm with a first measuring unit, which rpm is representative for an input shaft to the coupling, and a to measure a second rpm with a second measuring unit, which rpm is representative for the output shaft. In the case of a slipping coupling, the coupling’s input shaft and the coupling’s output shaft will rotate at slightly different rpms. Under otherwise constant conditions, the difference in rpms depends on the load under which the crusher is operating at that particular instant. The larger the difference in rpms, the greater the power which is transmitted to the crusher. The measuring units which are used to measure rpms are inexpensive and give very reliable measurement data.

According to a preferred embodiment, the slipping coupling has a first blade wheel and a second blade wheel, said blade wheels being separated by a gap, said first measuring unit being arranged to measure the rpm of the first blade wheel and said second measuring unit being arranged to measure the rpm of the second blade wheel. Slipping couplings usually incorporate at least two blade wheels, which are also known as impellers, wheels, rotors, etc. During operation, the housing of the slipping coupling and also the gap between the blade wheels contain hydraulic fluid. The viscosity of the
hydraulic fluid and the gap result in a tendency for the first blade wheel, which is powered by the drive unit, to pull the second blade wheel around with it. By directly measuring the respective rpms of the blade wheels it is simple to calculate a relationship between the rpms without needing to take into consideration gearing down and gearing up in transmissions.

The crushing plant preferably incorporates a calculating device which is arranged in such a way that the measured rpms and a calibration curve for the coupling are used to establish the torque which the output shaft transmits to the crusher. With the help of the calibration curve, the calculating device can use the rpms to calculate a value for the torque. The calibration curve is specific for a given coupling with a given hydraulic fluid and makes it possible to obtain a very reliable value for the torque in question. The calculating device can also measure very rapid changes in load, which means that faults can rapidly be corrected and damage can be avoided.

According to a preferred embodiment, a display device is arranged to show at least one value in a group of values which consists of the determined torque, a power calculated from the determined torque, a measured first rpm and a measured second rpm. The display of the values mentioned above gives an operator information about conditions in the crusher. The operator can then adjust the crusher so that the greatest possible production of crushed material is obtained within the limits prescribed for the values mentioned above. The operator can also discover faults in the crushing plant and the components which feed material and the operator also obtains an indication when the characteristics of the fed material change with respect to hardness and size, for example.

The crusher can be a gyratory crusher, a jaw crusher, a roll crusher or an impact breaker. All of
these types of crusher are driven by a drive unit and are subjected to varying loads depending on the hardness, flow rate, size, etc. of the fed material. Since the load is determined, the operation of the crusher can be improved with regard to the size of the crushed material and the amount of material which is crushed per unit of time, and damage can be avoided.

The crushing plant preferably has a control system which is intended to control the operation of the crusher in accordance with the determined torque. With the help of a reliable value for the torque, the control system makes it possible to obtain, without manual supervision, the maximum possible production of crushed material with as even a size distribution as possible. The control strategy can for example include the following parameters: The rate at which material is fed, the size of the fed material which arrives after crushing in a foregoing stage, the crusher’s rpm, the crusher’s crushing setting, etc. The control system can also incorporate alarm and emergency stop functions for the avoidance of injury to personnel and damage to equipment.

According to a preferred embodiment, the crusher is a gyratory crusher, and the control system is arranged in such a way that it controls the crushing setting of the gyratory crusher in accordance with the determined torque and signals from pressure and position sensors arranged on the gyratory crusher. The crushing setting of the crusher is a critical parameter for the operation of gyratory crushers. If the crushing setting is too large, the size of the crushed material increases and if the crushing setting is too small, the output of crushed material decreases and the load on the crusher increases, with a consequent risk of stalling. The position sensor measures the position of the crusher’s crushing shaft and indirectly the crushing setting, and the pressure sensor measures the pressure which affects the crusher’s crushing shaft in the vertical direction, to prevent the
crushing shaft from assuming an incorrect position with respect to the crusher’s fixed outer crushing mantle. With the help of the determined torque the control system can adjust the crushing setting in such a way that the crusher gives the highest possible production of crushed material whilst the crushing setting is controlled within certain predetermined limits.

According to a preferred embodiment, the crushing plant is a mobile crushing plant. In the case of mobile crushing plants it is sometimes desirable to connect to the coupling an external drive unit of arbitrary type and which is at the site to which the mobile crushing plant has been transported. It is common that mobile crushing plants are equipped with diesel engines due to a lack of access to a mains electricity supply at the site in question. These diesel engines often drive also other power consumers via a gearbox arranged between the engine and the coupling.

The object of the present invention is also to provide a method of monitoring the operation of a crushing plant, a method which is applicable with an arbitrary type of drive unit and gives reliable measurement of the crusher’s load, irrespective of the type of drive unit used.

This object is achieved with the help of a method of monitoring the operation of a crushing plant which comprises a crusher and a drive unit driving the crusher, said method being characterized by a coupling being driven by the drive unit, by the crusher being driven by an output shaft from the coupling and by the torque transmitted to the crusher by the output shaft being determined by a measuring device. As mentioned above, there are several advantages in the possibility of using an arbitrary type of drive unit.

Preferably, the coupling is an hydraulic slipping coupling and the drive unit is a diesel engine, and a first rpm, which is representative for the input shaft to
the coupling, and a second rpm, which is representative for the output shaft, are measured. For several reasons, crushing plants which have hydraulic slipping couplings driven by diesel engines are robust. On the one hand diesel engines are reliable and are not dependent on a mains electricity supply since they use a relatively easily handled fuel and on the other hand hydraulic slipping couplings facilitate starting and stopping procedures and reduce the risk of damage to engines and transmissions and injury to personnel, etc. Rpm measurement can be accomplished with high accuracy and reliability.

With the help of a calculation device, the torque transmitted to the crusher by the output shaft can conveniently be determined from the measured rpms and a calibration curve for the coupling. This determination can be made with high precision and in real time, thus permitting the optimisation of the crusher for a very high output of crushed material per unit of time within the size limits which have been established for the crushed material.

According to a specially preferred embodiment, the crusher is a gyratory crusher, with a control system used to control the crusher’s crushing setting with the help of the determined torque and signals from pressure and position sensors arranged on the crusher. As mentioned above, control of the crusher’s crushing setting makes it possible to optimise the operation of a gyratory crusher.

**Brief Description of the Drawings**

The invention is henceforth described in more detail below with the help of an embodiment and with references to the accompanying drawings.

Fig. 1 is a schematic representation of a crushing plant according to the present invention.
Fig. 2 shows a gyratory crusher which is incorporated in the crushing plant.

Fig. 3 is a schematic representation of an hydraulic slipping coupling which is incorporated in the crushing plant.

Fig. 4 shows a measuring device which is mounted on the slipping coupling shown in Fig. 3.

Fig. 5 shows a calibration curve for the slipping coupling.

Description of Preferred Embodiments

In Fig. 1 is shown a crushing plant 1. The crushing plant 1 has a drive unit 2 in the form of a diesel engine. The diesel engine 2 drives a shaft 3, which passes through a gearbox 4 and drives an hydraulic slipping coupling 5. The gearbox 4 is arranged to split power from the shaft 3 to a number of components which are incorporated in the crushing plant 1 but are not shown. The shaft 3 forms the input shaft to the slipping coupling 5. The slipping coupling 5 also has an output shaft 6 which, through a transmission 7 and a shaft 8, drives a gyratory crusher 9. The crusher 9 is fed with material by a feeding device 10, which feeds material to a hopper 11 mounted above the crusher 9.

A first rpm V1, which is representative for the input shaft 3 of the slipping coupling 5, is measured by an inductive first sensor 12. In the embodiment shown in Fig. 1, the first sensor 12 is arranged to measure the rpm of the first blade wheel 13 of the slipping coupling 5. Other rpsms which are representative for the shaft 3 can also be measured. As shown in Fig. 1, a sensor can be placed in any of several alternative positions 12'.

A second rpm V2, which is representative for the output shaft 6 of the slipping coupling 5, is measured by an inductive second sensor 14. In the embodiment shown in Fig. 1, the second sensor 14 is arranged to measure the rpm of the second blade wheel 15 of the slipping coup-
ling 5. Other rpms which are representative for the shaft 6 can also be measured. As shown in Fig. 1, a sensor can be placed in any of several alternative positions 14°.

The signals from the first sensor 12 and the second sensor 14 are received by a calculating device 16. The calculating device 16 utilizes a calibration curve K which applies for the slipping coupling 5 and the hydraulic fluid used. With the help of the rpms V1 and V2 and the curve K, the calculating device 16 can calculate the torque M which is currently transmitted to the crusher 9 by the slipping coupling 5.

The gyratory crusher 9 has a pressure sensor 17 and a position sensor 18, which are shown schematically in Fig. 2. The signals 17° and 18° from the sensors 17 and 18 respectively are processed in the collecting device 19.

The feeding speed of the feeding device 10 is controlled by a feeding control system 20. The crusher’s feed hopper 11 is fitted with a high level sensor 21 and a low level sensor 22. The feeding control system 20 controls the amount of material fed by the feeding device 10 in accordance with the level sensors 21 and 22.

A control system 23 receives signals from the calculating device 16 and from the collecting device 19. The control system 23 converts the determined torque M to a power E which is shown on a display or a presentation device 23°. The control system 23 also transmits a control signal to a control means 24. The control means 24 adjusts the crushing setting S (Fig. 2) which the control system 23 has selected with regard to the determined torque M, the position of the crushing shaft 25 of the crusher 9 and the pressure to which this shaft is subjected.

Fig. 2 shows a gyratory crusher 9 according to prior art. The crushing shaft 25, which, at its lower end 26 is eccentrically journalled, has an inner crushing member 27 which, by virtue of the simultaneous rotating and
pendulating motion of the crushing shaft 25, crushes material which has been fed into the upper part 28 of the crusher 9, against an outer crushing member 29. A crushing gap 30 is formed between the inner crushing member 27 and the outer crushing member 29. When the crushing shaft 25 is adjusted vertically by the control means 24, the crushing setting S of the crushing gap 30 is altered and thus the relationship between the amount of material which is crushed by the crusher 9 and the size of the material can be adjusted. If for some reason the torque M calculated by the calculating device 16 rises above a preset value, for example because of an unusually hard material entering the crusher, the control system 23, acting through the control means 24, temporarily increases the crushing setting S of the crusher 9 by lowering the crushing shaft 25. In this way more material, and also uncrushable objects, can pass through the crusher 9, which results in the torque M decreasing.

Fig. 3 shows a cross-section of the hydraulic slipping coupling 5. The shaft 3 is fixedly connected to a flange 31 which in turn is fixedly connected to the first blade wheel 13 and can thus rotate the first blade wheel 13. During operation, hydraulic fluid is continuously introduced to the slipping coupling 5 through an inlet I. The hydraulic fluid is then led between the first blade wheel 13 and the second blade wheel 15, which to a substantial degree is enclosed by the first blade wheel 13, and passes out through small gaps 32 between the blade wheels 13 and 15 and drain holes 32' in these wheels. The blade wheels 13 and 15 thus have no contact with each other but instead, the force is transmitted from the first blade wheel 13 to the second blade wheel 15 with the help of the viscosity of the hydraulic fluid. The coupling 5 has a housing 33 which collects the hydraulic fluid and leads it to a tank 33' at the bottom of the housing 33. The hydraulic fluid
is then drained out from tank 33° of the coupling 5 through a drain line U. The hydraulic fluid is then pumped by a pump 34 driven by the diesel engine 2 to a cooling circuit (not shown) to be subjected to a temperature-controlled cooling before it is returned to the inlet I in the coupling 5. When no power transmission is required in the coupling 5, a valve (not shown) is moved to a closed position so that the pump 34 pumps the hydraulic fluid directly to the tank 33° without the hydraulic fluid passing between the blade wheels 13, 15.

Fig. 4 shows a part of the slipping coupling 5. Four bolts 35 (of which only one is shown) are attached to the flange 31 and are distributed around the periphery of the flange at substantially equal intervals. The inductive first sensor 12 is mounted on a flange 36 which projects from the housing 33. The bolts 35 are adjusted so that they pass the sensor 12 at a small distance. A signal is generated in the connecting cable 37 of the sensor 12 each time a bolt 35 passes the sensor 12 during the rotation of the flange 31. The connecting cable 37 takes the signal from the sensor 12 to the calculating device 16. The second sensor 14 is arranged adjacent to the output shaft 6, in principle in the same manner as is shown in Fig. 4.

Fig. 5 shows a calibration curve K for the slipping coupling 5. The measured rpm V1, which is representative for the input shaft 3, is plotted on the x-axis. A calculation is made of the percentual difference P between the rpm V1 and the second measured rpm V2, which is representative for the output shaft 6, and this value P determines which curve is to be used. If for example the input rpm V1 is 2000 rpm and the output rpm V2 is 1900 rpm, the percentual difference P is thus (2000-1900)/2000 = 5%. When the rpm V1 = 2000 rpm is read off along the curve which corresponds to a 5% rpm difference, a transmitted torque M of 1680 Nm can be established on the y-axis, as shown in Fig. 5. If a calculating
device 16 is used, the calibration curve $K$ is converted in a manner well known to people skilled in this field into a mathematical relationship which provides very exact real-time values for the torque $M$.

It is understood that a multitude of modifications to the described embodiment are possible within the scope of the invention.

For example, the inductive sensors 12, 14, which are of the pulse-counting type, can be superseded by some other type of rpm detector, such as capacitive sensors, stroboscopes (pulsating light), limit switches or mechanical sensors with rollers. Diesel engines for example are often equipped with an internal tachometer. This could be used to measure rpm $V_1$. As mentioned above, there are numerous alternative positions 12° where a first sensor can be placed and numerous alternative positions 14° where a second sensor can be placed. The selection of positions is governed by considerations such as accessibility, easy installation, protected environment, etc.

The invention is suitable for several types of crusher. In addition to gyratory crushers 9, the method and device can also be used with for example jaw crushers, impact breakers and roll crushers.

The control system 23 can be of several types which are well known to people skilled in this field. An example of a suitable control system is ASR Plus™, which is marketed by Svedala-Arbrå, SE.

The hydraulic slipping coupling 5 can be either of the type which is continually fed with hydraulic fluid and thus completely ceases to transmit power when the supply of hydraulic oil is stopped, or of the type which always contains hydraulic oil and can therefore always transmit power.

The drive units 2 which above all are interesting are diesel engines, hydraulic motors and electric motors.
However, petrol engines and various kinds of turbines can also be of interest in special cases.

The torque $M$ can also be measured in other ways than by measuring rpms. For example, the output shaft 6 can be fitted with a strain gauge which is placed at a certain angle and which measures the torsion in the shaft 6. However, this arrangement is relatively complicated.

The output shaft 6 can be very short and connect the second blade wheel 15 to a transmission 7, which in turn drives the crusher 9. Alternatively, the output shaft 6 can drive the crusher 9 direct. The transmission 7 can also have a wheel which is mounted directly on the blade wheel 15 in such a way that the output shaft 6 is composed of the blade wheel and the wheel which is mounted on it.

In applications where automatic control of the crusher 9 is not necessary, the calculating device 16 can be connected to an indicating instrument which shows the current torque $M$. As mentioned above, the calculated torque $M$ is often converted into a power in kW which can then be shown on a presentation device 23°. This conversion can be incorporated as a function in the calculating device 16 or the control system 23 or accomplished in another way which is well known to people skilled in this field. In a simpler embodiment, only the measured rpms $V_1$ and $V_2$ are displayed. In all cases, the signals can be connected to an alarm function. The alarm function can give a warning both for an excessive torque, which can for example indicate too much or excessively hard material in the crusher, and for low torque, which can for example indicate a problem in the feeding device or in that part of the crusher to which the material is fed.

In the case of jaw crushers, impact breakers and gyratory crushers, for example, the power display mentioned above often gives the information which the operator needs in order to make sure that the maximum
possible amount of material is fed to the crusher. The operator is also given indications of faults. If for example a large object obstructs the crusher’s feed opening, the power drops considerably.
CLAIMS

1. A crushing plant which comprises a crusher (9) and a drive unit (2) which drives the crusher (9), characterized by the drive unit (2) being arranged to drive a coupling (5), which, through an output shaft (6) from the coupling (5), transmits power to the crusher (9), and by the crushing plant incorporating a measuring device (12, 14, 16), which is arranged to determine the torque (M) which the output shaft (6) transmits to the crusher (9).

2. A crushing plant according to claim 1, wherein the drive unit (2) has been selected from a group consisting of internal combustion engines and hydraulic motors.

3. A crushing plant according to any of the preceding claims, wherein the drive unit (2) is a diesel engine.

4. A crushing plant according to any of the preceding claims, wherein the coupling (5) is an hydraulic slipping coupling.

5. A crushing plant according to claim 4, the measuring device (12, 14, 16) of which is so arranged that a first measuring unit (12) determines a first rpm (V1), which is representative for an input shaft (3) of the coupling (5), and a second measuring unit (14) determines a second rpm (V2), which is representative for the output shaft (6).

6. A crushing plant according to claim 5, the slipping coupling (5) of which has a first blade wheel (13) and a second blade wheel (15), with the blade wheels (13, 15) being separated by a gap (32) and with the first measuring unit (12) being arranged to measure the rpm of the first blade wheel (13) and the second measuring unit (14) being arranged to measure the rpm of the second blade wheel (15).
7. A crushing plant according to claim 5 or 6, which has a calculating device (16) arranged in such a way that the determined rpms (V1, V2) and a calibration curve (K) for the coupling (5) are used to determine the torque (M) which the output shaft (6) transmits to the crusher (9).

8. A crushing plant according to any of the preceding claims, in which a presentation device (23') is arranged to show at least one value from the group of values consisting of the determined torque (M), a power (E) calculated from the determined torque (M), a measured first rpm (V1) and a measured second rpm (V2).

9. A crushing plant according to any of the preceding claims, wherein the crusher (9) is a gyratory crusher, a jaw crusher or an impact breaker.

10. A crushing plant according to any of the preceding claims, being equipped with a control system (23) which is intended to control the operation of the crusher (9) in accordance with the determined torque (M).

11. A crushing plant according to claim 10, with the crusher (9) being a gyratory crusher and with the control system (23) arranged in such a way that the crushing setting (S) of the gyratory crusher (9) is controlled in accordance with the determined torque (M) and signals from pressure (17) and position (18) sensors.

12. A crushing plant according to any of the preceding claims, said crushing plant being a mobile crushing plant.

13. A method of monitoring the operation of a crushing plant which contains a crusher (9) and a drive unit (2) driving the crusher (9), characterized by the coupling (5) being driven by a drive unit (2), by the crusher (9) being driven by an output shaft (6) from the coupling (5) and by the torque (M) which the output shaft (6) transmits to the crusher (9) being determined with the help of a measuring device (12, 14, 16).
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B02C 25/00
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)

IPC7: B02C

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

SE, DK, FI, NO classes as above

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

WPI DATA, EPO-INTERNAL, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>X</td>
<td>US 4298113 A (MARVIN B. SHAVER ET AL), 3 November 1981 (03.11.81), column 1, line 1 - line 11; column 1, line 61 - line 67; column 2, line 33 - line 47, column 2, line 58 - line 62; column 4, line 26 - line 29; column 4, line 44 - line 47, claims 1,6, abstract</td>
<td>1, 5-9-10, 12-14</td>
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<tr>
<td>X</td>
<td>US 5215263 A (HERMANN GETZMANN), 1 June 1993 (01.06.93), column 1 - column 2, abstract</td>
<td>1-5,9-10, 12-14</td>
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<tr>
<td>A</td>
<td>US 4609155 A (THOMAS J. GARNIER), 2 Sept 1986 (02.09.86), column 1, line 6 - line 10; column 2, line 1 - line 38; column 3, line 3 - line 19, column 4, line 33 - column 5, line 58, figure 1, claim 1, abstract</td>
<td>1-5,9-10, 12-14</td>
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[X] Further documents are listed in the continuation of Box C. [X] 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
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Date of the actual completion of the international search

9 January 2002

Date of mailing of the international search report

3 0-01- 2002

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Swedish Patent Office
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Authorized officer

Susanna Hurtig/ELY
Telephone No.  +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)
### DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Relevant to claim No.</th>
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<tr>
<td>A</td>
<td>DE 4422937 A1 (STAMAG STAHL- UND MASCHINENBAU AG), 4 January 1996 (04.01.96), column 1, line 1 - line 14; column 2, line 1 - line 52, claims 1,2, abstract</td>
<td>1-5,9-10, 12-14</td>
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Form PCT/ISA/210 (patent family annex) (July 1998)