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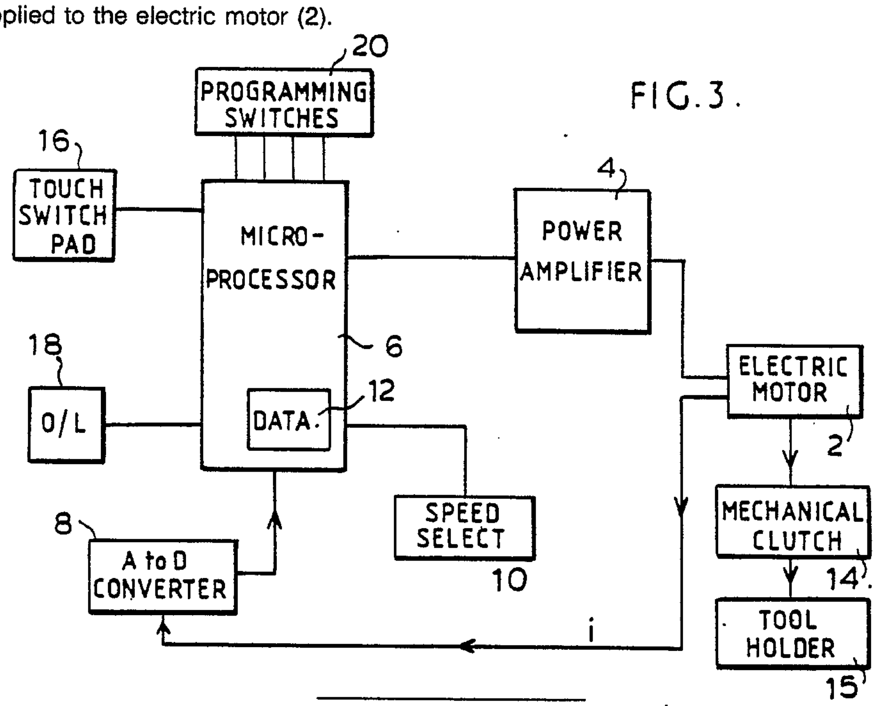
(54) Power tool with torque control.

(57) A power tool, such as a screwdriver, comprises an electric motor for driving a tool holder (15), a generator means (6) for generating a signal indicative of torque across the electric motor (2), and means for switching substantially full power to the electric motor (2) when the torque is equal to or greater than a preset torque datum (T_d). A mechanical clutch 14 is provided for cutting-off the drive to the tool holder (15) in response to substantially full power being supplied to the electric motor (2).

FIG.3.



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Power Tools

This invention relates to power tools and in particular to power tools equipped with a device for cutting-off drive when the torque across the tool holder has reached a preset torque datum.

A power tool which has a device for cutting-off drive is described in United Kingdom Patent No. 2 096 510B. In this power tool, the device is in the form of a clutch operatively connected between a motor and a tool holder. The clutch comprises torque sensitive clutch members which move axially relative to each other when a torque above a preset value is transmitted across the clutch. This relative movement gives rise to relative movement between members of a Hall effect device which causes the motor to be cut-off. The clutch disengages the tool holder from the motor. In order to vary the torque at which the clutch disengages the tool holder from the motor, a compression spring in the clutch can be adjusted by being tightened or loosened.

This power tool is disadvantageous in that it operates at full power regardless of the torque setting which gives rise to a significant amount of inertia in the motor, gearing and the tool holder because full power is being supplied to the motor prior to cut-off. This gives rise to an indeterminate torque across the tool holder after cut-off, the value of this torque and rate at which it decays depending upon the friction between the tool and the workpiece, the inertia of the tool, tool holder, motor and gearing at cut-off.

The indeterminate torque gives rise to an undesirable degree of unpredictability in the operating characteristics of the power tool.

There has been proposed a clutchless power tool in which the torque across the tool holder is monitored, for example by measuring current supply in the case where the drive is an electric motor. In this power tool the power supply to the motor is cut-off when the torque reaches the preset level. This type of clutchless power tool also suffers from inertia problems.

A previously proposed solution is to provide a power tool which has a variable free running speed, the cut-off being effected by means of a clutch or by current measurement as described above. Such power tools are disadvantageous because they cannot achieve high torques at low speeds.

It is an aim of the present invention to provide a power tool which alleviates the aforementioned disadvantages so as to allow greater precision in cut-off torque adjustability while minimising undesirable torques after cut-off.

According to the present invention there is provided a power tool comprising drive means for driving a tool holder, generator means for generating a signal indicative of torque across the drive means, means for switching substantially full power to the drive means when the torque is equal to or greater than a preset torque datum, and clutch means for cutting-off the drive to the tool holder in response to substantially full power being supplied to the drive means.

The torque datum may be the value of the torque across the drive means when the speed of the drive means is substantially equal to zero due to loading on the tool holder. Setting means may be provided for setting the value of the torque datum in dependence upon the free-running speed of the drive means.

Switch means may be operatively associated with the clutch means for switching off the power to the drive means when the clutch means cuts-off the drive to the tool holder. The switch means may be in the form of a Hall effect switch or a lever type switch.

The drive means may comprise an electric motor and the torque across the drive means may be measured in dependence upon current supplied to the electric motor.

The clutch means is preferably adjustable so that the torque at which it is operative for cutting-off the drive can be maintained greater than the torque datum.

A programmable microprocessor is preferably operative for determining the torque datum which corresponds to a given free-running speed by way of inspection of a pre-programmed set of corresponding torque data and free-running speed values. The programmable microprocessor may be operative for comparing the signal indicative of the torque across the drive means with the preset torque datum and for switching the drive means to full power when the torque is equal to or greater than the preset torque datum. The switch means may be incorporated into the microprocessor so that the microprocessor switches off the power supply to the motor immediately before the clutch means cuts-off drive to the tool holder.

Programming switches may be associated with the programmable microprocessor for setting an operating mode of the power tool, for example, for setting the tool to be switched on/off in response to axial movement of the holder instead of by a manual switch. Additionally, the programming switches may provide means for switching the power tool to operate in forward or reverse functions.

The invention will now be further described by way of example, with reference to the accompanying drawings, in which:

Figure 1 illustrates variation of torque with time for a number of operating conditions of a power tool on a range of joints;

Figure 2 shows the relationship between torque data and a range of free-running speeds;

Figure 3 shows a schematic diagram of a power tool embodying the present invention; and

Figure 4 illustrates variation of torque with time in relation to a preset torque datum T_d for an embodiment of the present invention.

In Figure 2, four curves a to d show variation of torque before and after a preset cut-off torque $T_p$against time for a clutchless power tool (not shown), in the form of a screwdriver, which is driven by an electric motor (not shown).

The curve a shows torque variations when the screwdriver is used to tighten a screw into a hard stop, the torque across the motor rises steeply as the screw is tightened. The torque across the electric motor is proportional to the electric current supplied to the motor and so by measuring the current an indication of the torque can be derived. When the magnitude of the torque has reached a predetermined level T_p the power to the electric motor is switched off. The screwdriver however continues to turn due to inertia of the rotating parts (ie, tool holder, gearing and electric armature). The torque across the electric motor continues to rise for a short time after the cut-off and then decays to zero as the speed of the screwdriver reaches zero. Curves b, c, and d show different profiles of torque variation in the case where the screwdriver is used to drive in screws into softer materials.

Figure 2 illustrates how the torque varies with speed of the power tool for four different free-running speeds e to h. For example, in the case where full power is being supplied to the electric motor, the free-running speed of the screwdriver may be 1000 revolutions per minute (r.p.m). If a steadily increasing torque is applied across the electric motor, the speed of the screwdriver will steadily decrease until the electric motor stalls. In the case of e, the torque at which the electric motor stalls represents the maximum torque T_m which the power tool is capable of supplying. If the initial free-running speed of the electric motor is 800 revolutions per minute then the maximum torque which can be supplied by the power tool is correspondingly lower (line f). Hence, by varying the free-running speed of the electric motor, the maximum torque which can be supplied by the power tool can be varied accordingly. If it is desired to have a preset torque datum T_d, then this may be achieved by setting the power tool to run at its maximum free-running speed of 1000 rpm and then cutting-off the power supply to the electric motor or disengaging the screwdriver and tool holder from the motor when the required torque datum T_d is reached. However, in this case the speed of the screwdriver at cut-off is 850 rpm and so considerable inertia remains in the system.

In order to minimize the remaining inertia, the free-running speed may be set at 200 rpm (see line h of Figure 2) and so when the torque across the electric motor has reached the required torque datum T_d, the speed of the screwdriver is substantially equal to zero and so very little inertia remains. Hence, if the screwdriver and tool holder is disengaged from the electric motor when this point is reached the inertia remaining in the motor and tool holder is much smaller.

The actual initial free-running speed may be set slightly higher than the theoretical value, say 220 rpm for the torque datum T_d. This is due to resistive and frictional effects of gearing etc.

In practice, a certain amount of inertia will remain in the tool holder and screwdriver and so the absolute maximum torque is still slightly greater than the torque datum. This may be compensated for by setting a slightly lower torque datum than the desired maximum torque to be reached.

In Figure 3 there is shown a schematic diagram of a power tool embodying the present invention.

In Figure 3 an electric motor 2 is powered by a power amplifier 4 which is coupled to a microprocessor 6. The microprocessor 6 is operative for controlling the power supplied to the electric motor 2 by the power amplifier 4 in dependence upon the torque across the electric motor 2. An AD converter 8 receives a signal representative of the current i supplied to the electric motor and generates a digital signal indicative of the torque across the electric motor 2 and supplies this to the microprocessor 6.

A setting means which in this case is a speed select switch 10, sets the free running speed of the motor 2 and the datum torque T_d (that is, the datum torque at which full power is to be switched on). The microprocessor 6 comprises a data memory 12 which may be in the form of a read only memory (ROM) which stores tables of torque data corresponding to different free-running speeds. The microprocessor 6 is operative for comparing the digital signal representative of the torque across the electric motor 2 received from the AD converter 8 with the value of the present torque datum T_d which corresponds to the speed selected by the speed select switch 10.

When the torque across the electric motor 2 has reached the preset torque datum T_d, the microprocessor 6 switches the power amplifier 4 to supply full power to the electric motor 2. In response to full power being supplied to the electric motor 2, a mechanical clutch 14 responds immediately to the sudden increase in torque across the electric motor 2 so as to disengage the electric motor from a tool holder 15. Just before the tool holder 15 is disengaged, a Hall effect switch (not shown), which is associated with the mechanical clutch 14, generates a signal whic is fed to the microprocessor 6. On receipt of the signal, the microprocessor 6 switches off the power supply to the electric motor 2.

Applying full power to the electric motor 2 when the preset torque datum T_d is reached has the advantage that the rotating parts of the tool do not have a significant amount of inertia because the parts are rotating slowly. Hence, the torque/time graph is similar to that of curve 'd' in Figure 1 regardless of the joint. Consequently, for various types of joint, for example, hard or soft joints, the torque achieved is substantially constant.

Figure 4 shows an example of torque against time for an embodiment of the invention where the torque datum has been set at T_d and the maximum torque desired is T_{max}. When the torque datum T_d is reached (at point A of Figure 4), the screwdriver is supplied with full power and the torque increases until the clutch setting is reached (P of Figure 4 indicates the point at which the mechanical clutch 14 is set to disengage the tool holder 15 from the electric motor 2) at which point the motor power is cut off, and disengagement of the output drive occurs.

Embodiments of the present invention are advantageous in that the relatively low residual inertia of the tool holder 15 after disengagement enables a more precise determination of torque and provides for the possibility of obtaining a high torque at a relatively low speed.

A touch switch pad 16 may be provided on the tool and is connected to the microprocessor 6 in order to provide an on/off switch for the power tool. An overload detecting means 18 is also associated with the microprocessor 6 in order electrically to disconnect the electric motor 2 from the tool holder and/or to disconnect the power supply from the power amplifier 4 in the case where there is an overload due to over-heating or the like.

Four programming switches 20 may be coupled to the microprocessor 6 to enable the power tool to be programmed to operate in any one of up to sixteen modes. For example, one switch may be operative for setting the microprocessor to be switched on/off in response to axial movement of the tool holder instead of by the touch switch pad 16. In addition, one of the programming switches may be operative for providing a slow start feature. Such a feature is useful in the case where the screwdriver is intended for delicate work where it may be desired to start the screwdriver slowly (thereby giving the operator time to locate the screwdriver accurately in the screw head) and to increase speed gradually.

Claims

1. A power tool comprising drive means (2) for driving a tool holder (15), generator means (6) for generating a signal indicative of torque across the drive means (2), means for switching substantially full power to the drive means (2) when the torque is equal to or greater than a preset torque datum (T_d) and clutch means (14) for cutting-off the drive to the tool holder (15) in response to substantially full power being supplied to the drive means (2).

2. A power tool according to claim 1, wherein the torque datum is the value of the torque across the drive means (2) when the speed of the drive means (2) is substantially equal to zero due to loading on the tool holder (15).

3. A power tool according to claim 1 or claim 2, wherein switch means is operatively associated with the clutch means (14) for switching off power supplied to the drive means (2) when the clutch means (14) cuts-off the drive to the tool holder (15).

4. A power tool according to claim 3, wherein the switch means is a Hall effect switch or a lever type switch.

5. A power tool according to any one of the preceeding claims, wherein the drive means (2) comprises an electric motor, and the torque across the drive means (2) is measured in dependence upon current supplied to the electric motor.

6. A power tool according to any one of the preceeding claims, wherein the clutch means (14) is adjustable so that the torque at which the clutch means (14) is operative for cutting-off the drive can be maintained greater than the torque datum.

7. A power tool according to any one of the preceeding claims, wherein setting means is provided for setting the value of the torque datum in dependence upon the free-running speed of the drive means (2).

8. A power tool according to claim 7, wherein a programmable microprocessor is provided for determining the torque datum which corresponds to a given free-running speed.

9. A power tool according to claim 8, wherein the torque datum is determined by way of inspection of a pre-programmed set of torque datum and free-running values.

10. A power tool according to claim 8 or claim 9, wherein the programmable microprocessor is operative for comparing the signal indicative of the torque across the drive means (2) with the preset

torque datum (T_d) and for switching the drive means (2) to full power when the torque is equal to or greater than the preset torque datum (T_d).

11. A power tool according to any one of claims 8 to 10, wherein programming switches (20) are associated with the programmable microprocessor (6), which switches are operative for setting an operating mode of the power tool.

12. A power tool according to claim 11, wherein the programming switches (20) provide means for switching the power tool to operate in forward or reverse functions.

13. A power tool according to any one of claims 8 to 12, when dependent upon claims 3 and 7, wherein the switch means is incorporated into the programmable microprocessor so that the microprocessor is operative for switching off the power supply to the drive means (2) immediately before the clutch means (14) cuts-off drive to the tool holder (15).

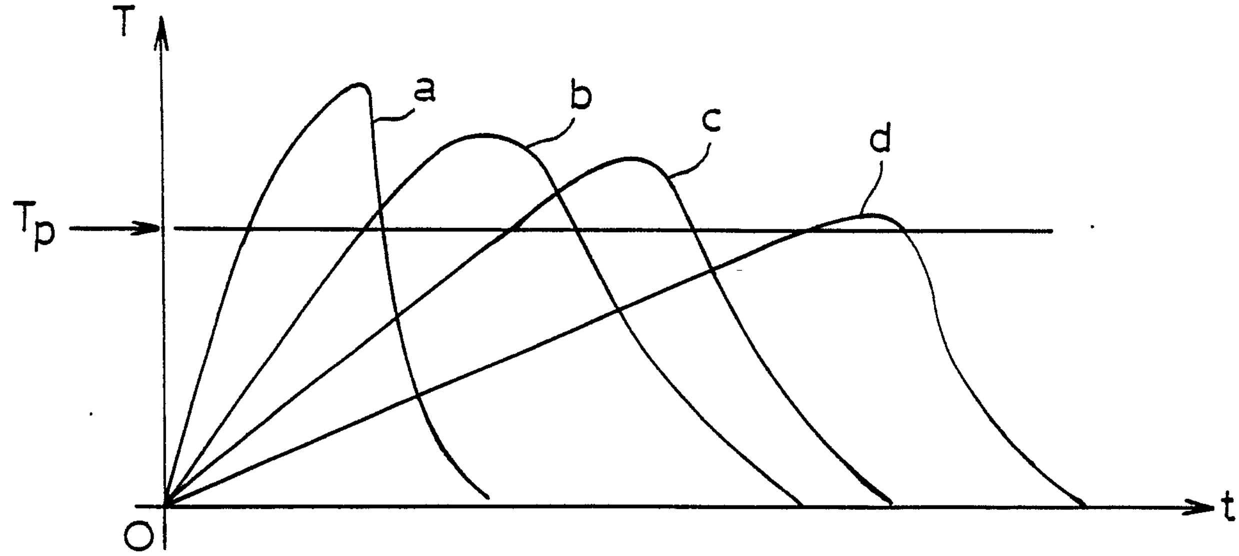

FIG. 1.

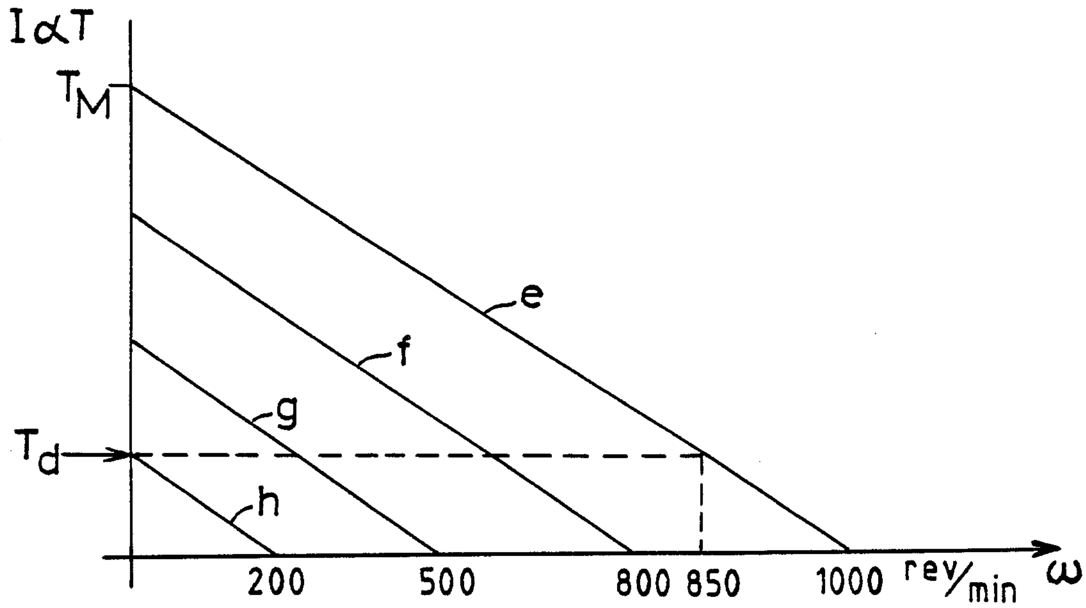

FIG. 2.

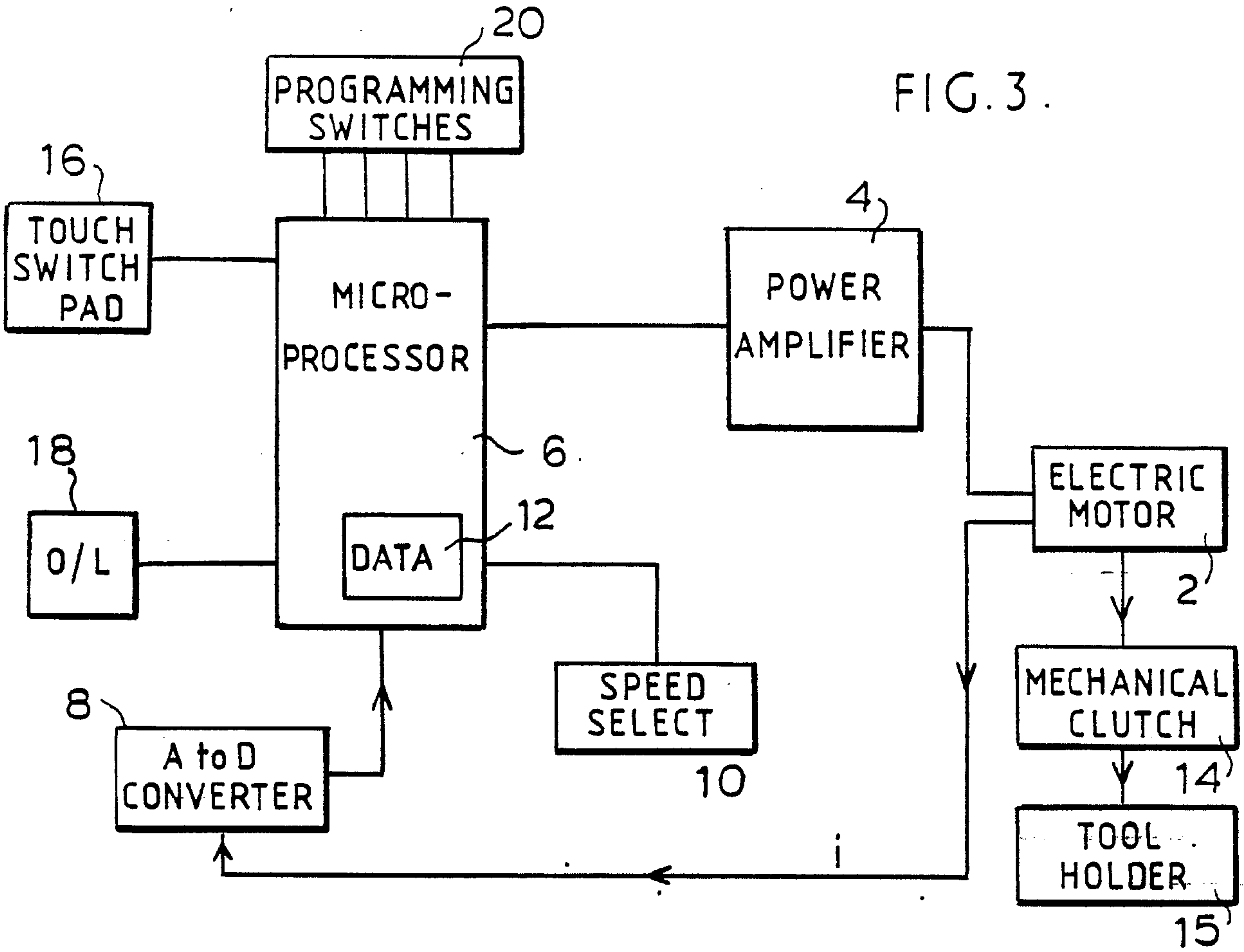
20
PROGRAMMING SWITCHES
16
TOUCH SWITCH PAD
MICRO-PROCESSOR
6
4
POWER AMPLIFIER
18
O/L
DATA
12
ELECTRIC MOTOR
2
8
A to D CONVERTER
SPEED SELECT
10
MECHANICAL CLUTCH
14
TOOL HOLDER
15
i

FIG.3.

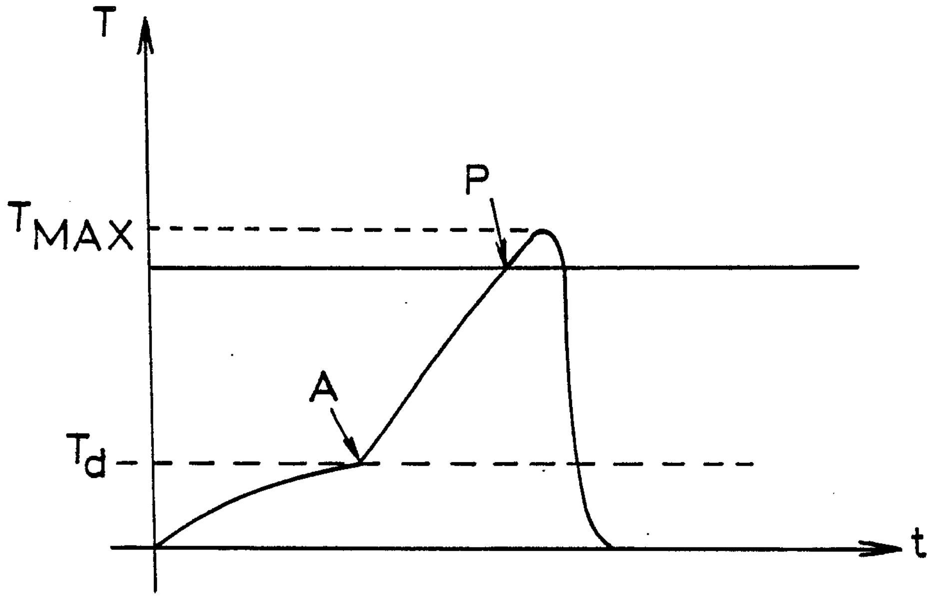
T
P
T_{MAX}
A
T_d
t

FIG.4.

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 87308677.1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 4)
D,Y	EP - A2 - 0 063 460 (DESOUTTER LTD.) * Abstract; claims; fig. 1,2 * --	1,2,3, 4,6,7, 12	B 25 B 23/14
Y	EP - A2 - 0 066 385 (FORD FRANCE S.A.) * Page 3, lines 6-25; page 12, lines 9-14; page 15, lines 23-26; page 19, lines 2-5 * --	1,2,8, 9,10, 13	
A	DE - A1 - 2 835 382 (C & E FEIN GMBH & CO) * Claim 1; fig. 3,4 * --	5	
A	GB - A - 1 481 093 (SHIBAURA ENGINEERING WORKS) * Claim 4 * ----	5	TECHNICAL FIELDS SEARCHED (Int. Cl.4) B 25 B 21/00 B 25 B 23/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	03-12-1987	BENCZE

CATEGORY OF CITED DOCUMENTS

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