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(54) Process and Apparatus for Fixing Measuring Range Limits for Tests on a Tooth-flank Tester

(57) A tooth-flank tester comprises a feeler (28) mounted on an X- and Y-slide arrangement (12x, 14x; 12y, 14y), and connected to a computer (32). A memory (34) of the computer has storage positions (34k, 34f) for adjustable end limits of the measurement range of the feeler. Also connected to the computer is a changeover switch (36) which connects an X-position controller (26x) optionally to the computer (32) or to the feeler (28) and which is, in turn, switchable via the computer. The measurement signal of the feeler (28) can therefore be utilised, via this changeover switch, directly and exclusively to control an X-position drive (18x). By means of this measure it becomes possible to move the feeler (28) against the tooth flank (10), without damage to its highly sensitive measuring system, when setting the end limits.

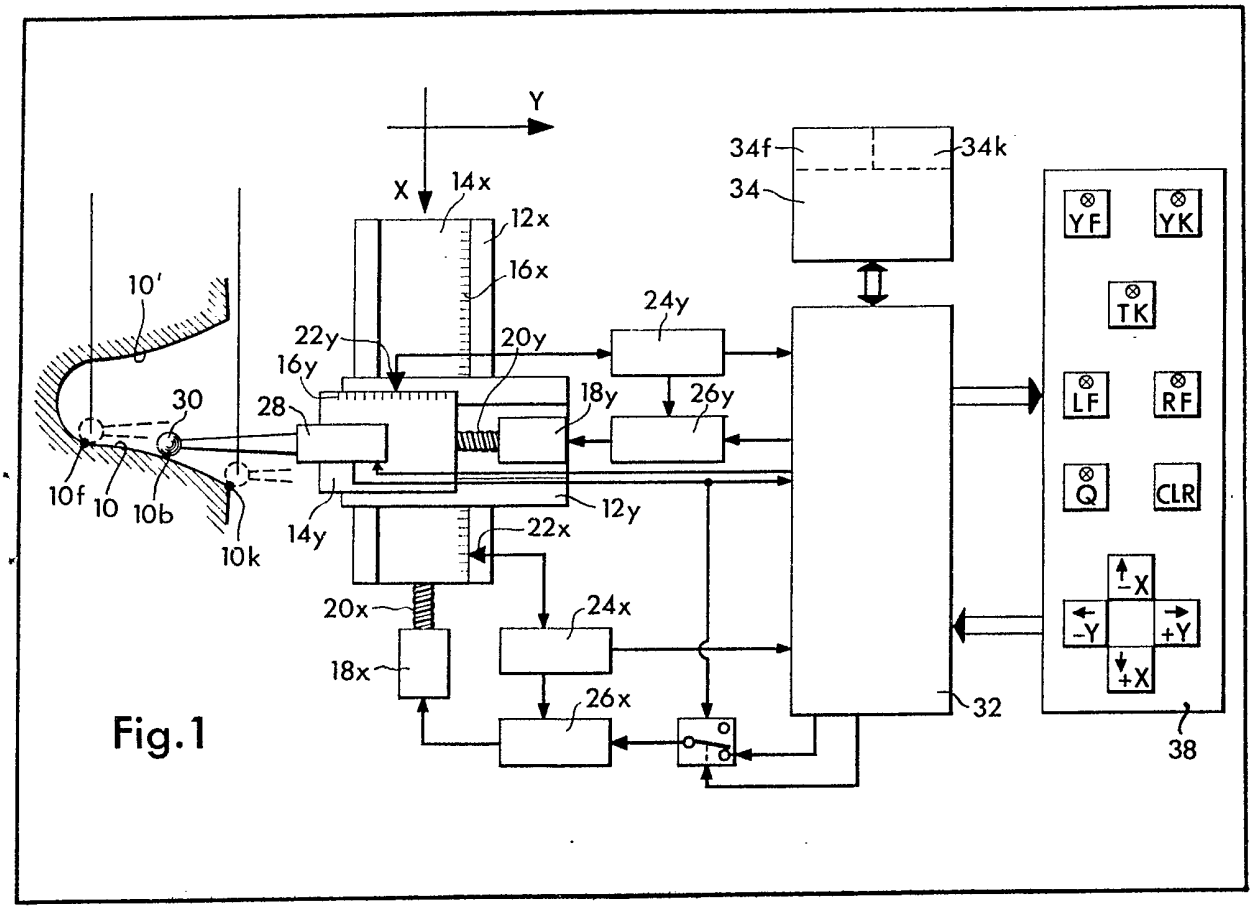

Fig.1

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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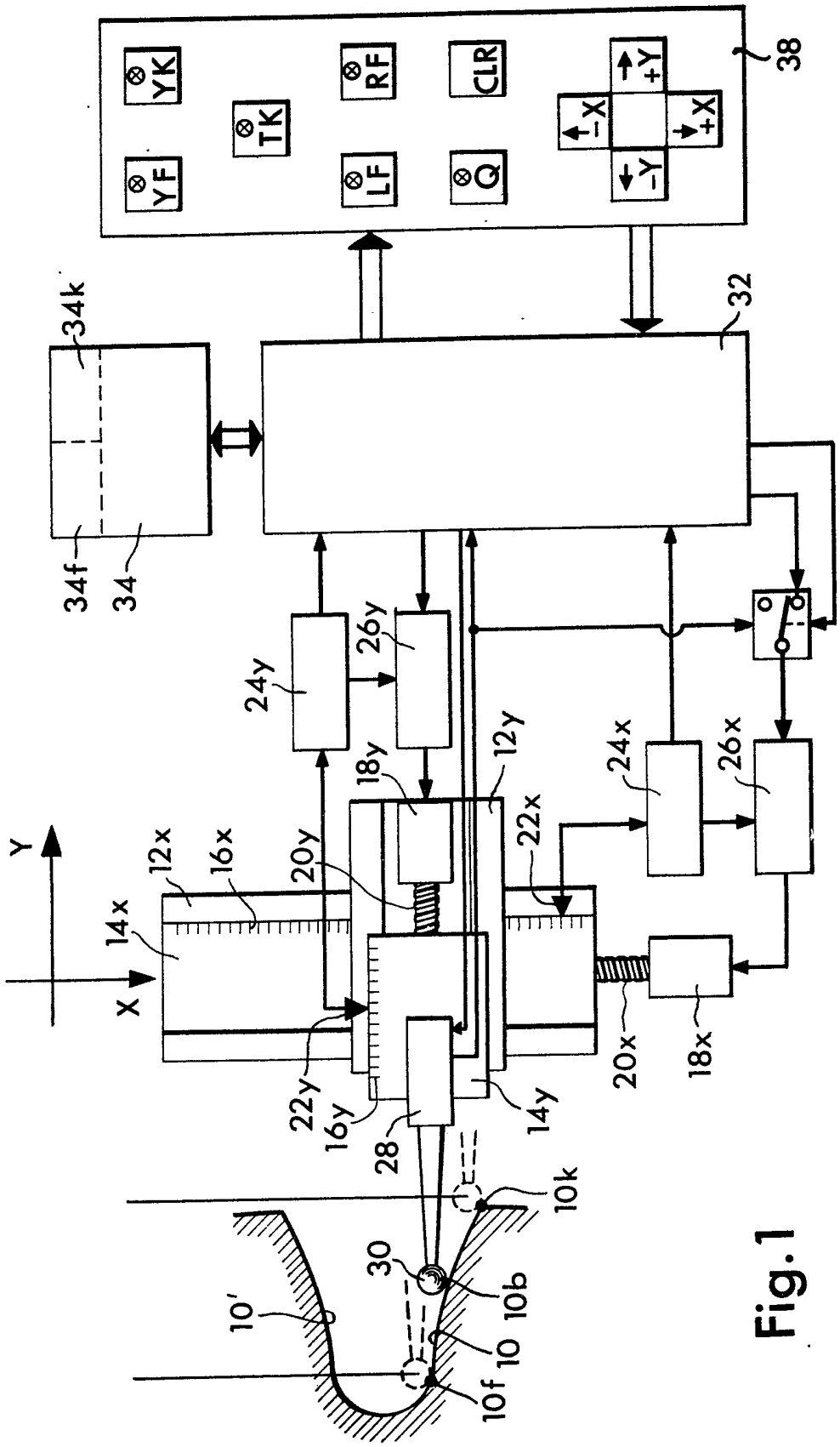

Fig.1

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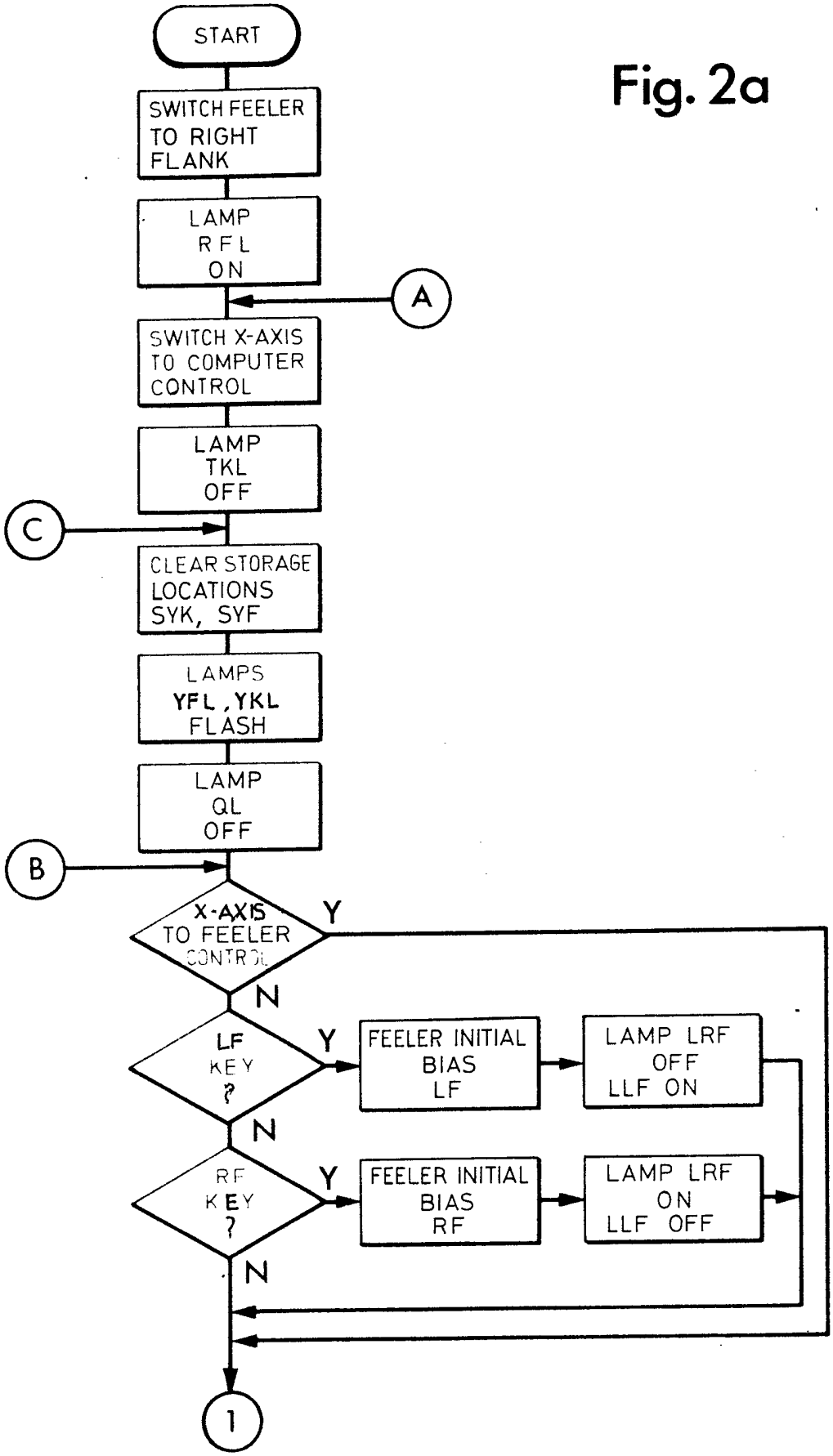

Fig. 2a

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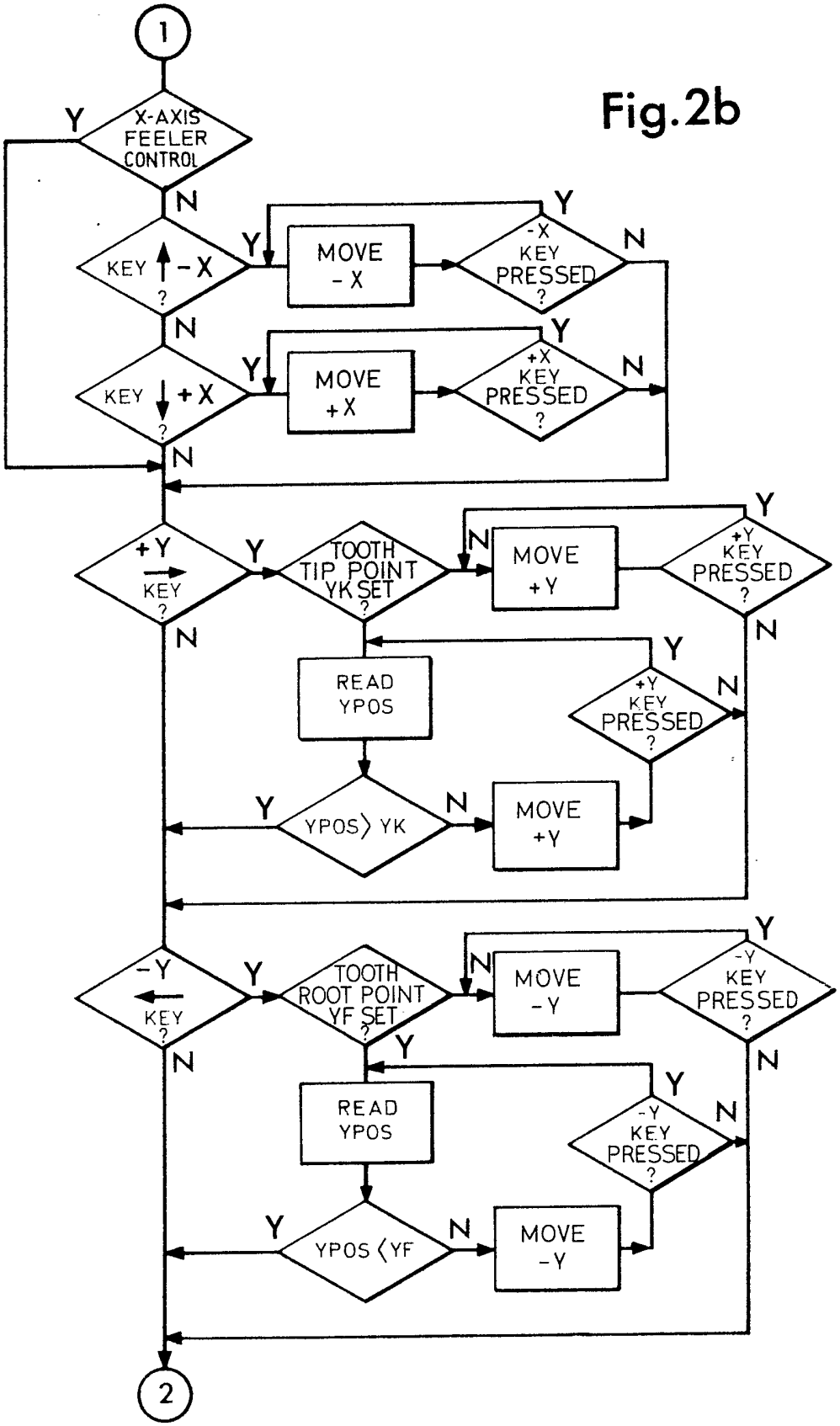
Fig.2b



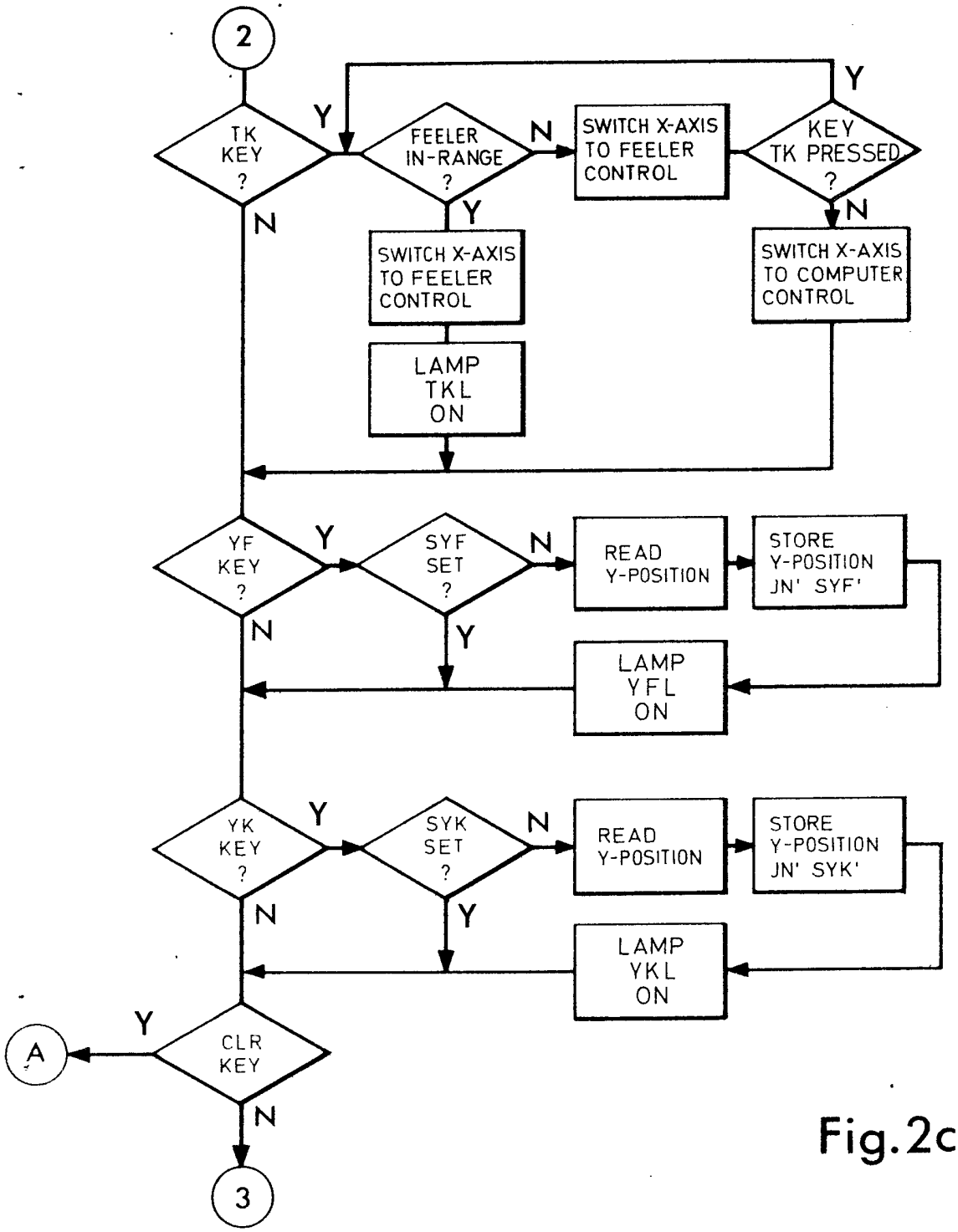

2
TK KEY ?
Y
N
FEELER IN-RANGE ?
N
Y
SWITCH X-AXIS TO FEELER CONTROL
KEY TK PRESSED ?
Y
N
SWITCH X-AXIS TO FEELER CONTROL
SWITCH X-AXIS TO COMPUTER CONTROL
LAMP TKL ON
YF KEY ?
Y
N
SYF SET ?
N
Y
READ Y-POSITION
STORE Y-POSITION JN' SYF'
LAMP YFL ON
YK KEY ?
Y
N
SYK SET ?
N
Y
READ Y-POSITION
STORE Y-POSITION JN' SYK'
LAMP YKL ON
CLR KEY
Y
N
A
3

Fig.2c

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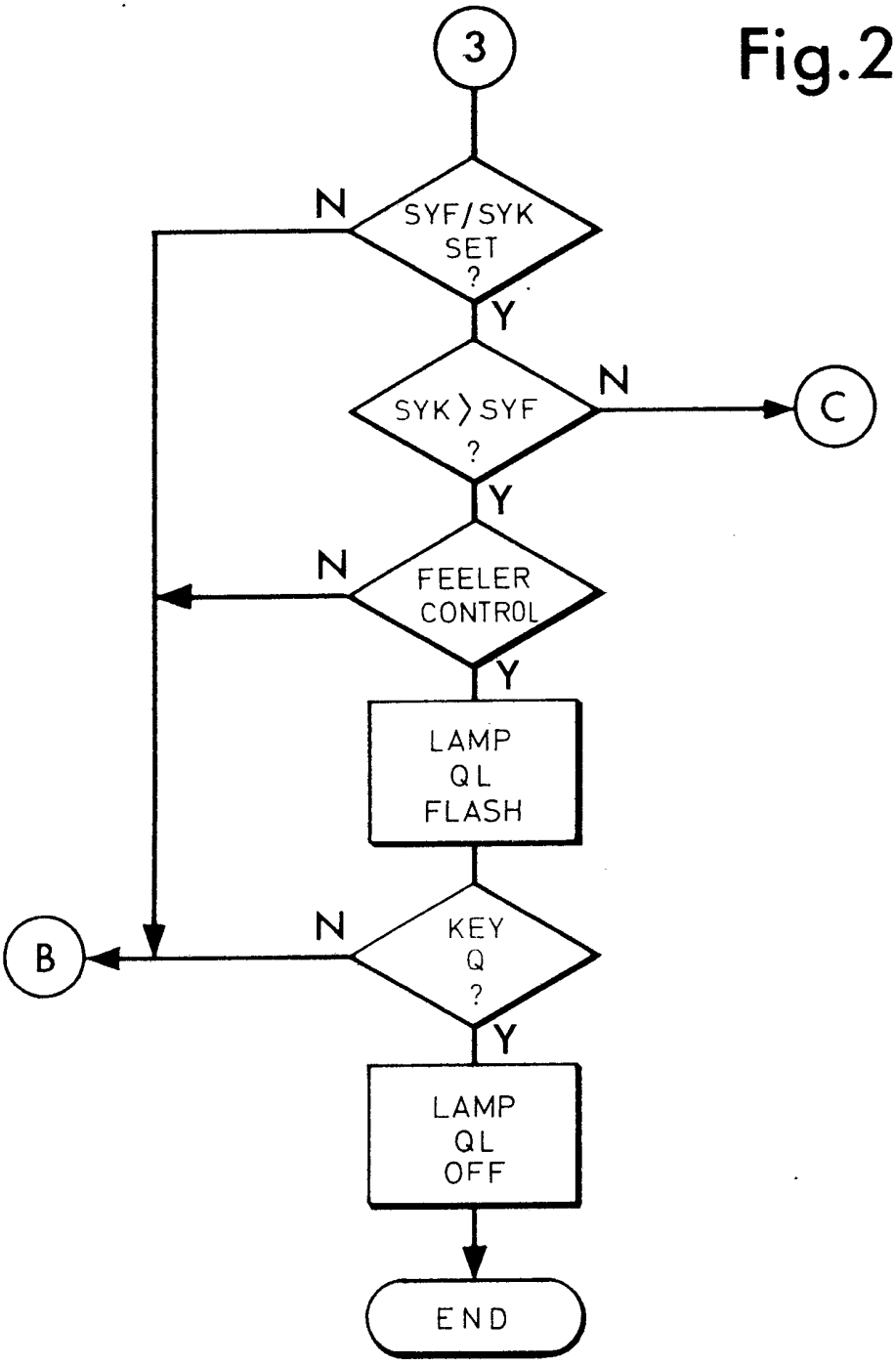
Fig.2d



SPECIFICATION

Process and Apparatus for Fixing Measuring Range Limits for Tests on a Tooth-flank Tester

The invention relates to a process and apparatus for fixing measuring range limits on a tooth-flank tester.

Tooth flank testers are known in which a feeler comprising a deflectable probe is arranged on a cross-slide arrangement having an X-slide movable in the direction of the tooth width of a test piece and a Y-slide movable in the direction of the tooth depth, and X- and Y-drives with respective X- and Y-servo-motors. Respective position indicators and position controllers are assigned to each of these slides, and both drives are controllable optionally manually or by a program-controlled computer which processes, in addition to signals from the position indicators, also signals transmitted from the feeler itself in accordance with the deflection of its probe and which interrupts the program cycle when the deflection exceeds a predetermined amount, and in which a memory for the position data of a tooth tip point and of a tooth root point as limits of the measuring range to be covered by the probe on as many tooth flanks as desired is connected to the computer. In these testers the probe is moved into the tip point or root point and the position data obtained there from the feeler is stored.

With such tooth-flank testers —embodiments are described in German Patent Applications P29 34 347.3 and P 29 34 412.5 —the feelers have a measuring range from about 7 to 40 μ. These are, therefore, extremely sensitive instruments which must be handled with care. In order to prevent the feeler from being deflected beyond its measuring range and thereby overloaded when its probe meets a tooth flank or another object, it is ensured that the computer interrupts the program cycle and stops all the drives when the deflection of the feeler exceeds a predetermined amount.

However, considerable difficulties can arise from this indispensable safety measure in the fixing of the limits of a measuring range which the probe must cover repeatedly to test a plurality of tooth flanks of a testpiece or several identical testpieces. In many cases, the limits of the measuring range do not arise simply from the toothing data, but must first be fixed on the test piece itself before they can be fed into the memory. It is conventional to conduct this investigation by moving the probe, by manual control of the X-drive and of the Y-drive, consequently to the two points of a tooth flank which are to constitute the limits of the measuring range as tooth tip point and as tooth root point and which are fixed by the user of the tooth-flank tester in such a way that, firstly the tooth-flank profile is tested over the relevant length and, secondly, there are avoided the disturbances of the automatic measuring operation that would occur if the probe butts against a tooth bottom or the probe slips off a tooth face.

It has proved extremely difficult in many cases to bring the probe into a desired root or tip point by manual control of the X- and Y-drives and, in so doing, to ensure that the feeler is deflected at the respective point within given limits. If the maximum permissible deflection is exceeded, the safety measure described becomes effective and the whole attempt to approach the tooth root or tip point provided must be repeated. Such misfortune befalls even experienced users of known tooth-flank testers particularly frequently when the purpose is to reach an apparently suitable root point in a narrow tooth space with the probe, since, there, the probe can butt not only against the tooth flank, but also against the tooth bottom. Difficulties can arise in this region also due to the fact that the tooth root is undercut and it is necessary to prevent the probe from passing beyond the tooth flank into the undercut region.

On the other hand, in the attempt to reach the desired tooth root point or tip point, it is also necessary to prevent the probe from being deflected too little at this point, when the position data of the two slides is stored. Too small a deflection of the probe means that the probe rests against the tooth flank with too small an initial bias and, consequently, when this and further tooth flanks are subsequently traced or scanned, it is incapable of supplying consistent results of measurement.

The object of the present invention is therefore to make it easier for a user to reach with a large degree of accuracy a root or tip point selected by him and there to achieve a deflection of the feeler which lies within prescribed limits.

According to one aspect of the invention, there is provided a process for fixing one or both limits of a measuring range of a tooth-flank tester, in which a feeler comprising a deflectable probe is arranged on a cross-slide arrangement having an X-slide movable in the direction of the tooth width of a test piece and a Y-slide movable in the direction of the tooth depth, and X- and Y-drives with respective X- and Y-servomotors and respective position indicators and position controllers for each of said slides, both drives being controllable optionally manually or by a program-controlled computer which processes signals from the position indicators and also signals transmitted from the feeler itself in accordance with the deflection of its probe and which interrupts the program cycle when the deflection exceeds a predetermined amount, and in which a memory for the position data of a tooth tip point and of a tooth root point as limits of the measuring range to be covered by the probe is connected to the computer, for the fixing of said limit(s) the probe being moved to any desired point between and spaced from two adjacent tooth flanks of the test piece, the X-position controller being then connected to the feeler, while bypassing the computer, the probe being brought to rest against a point of one of these flanks by means of a movement of the X-slide

controlled by the feeler and being thereby deflected by the predetermined amount and, with the X-slide continuing to be controlled by the feeler itself, the probe being then moved, by manual control of the Y-slide, along the tooth flank to the tooth tip point and/or the tooth root point and the position data obtained there being stored to fix said limit(s).

It is possible for the user initially to control manually firstly the Y-slide and, if necessary, also the X-slide, in such a way that the probe arrives at any point desired, preferably approximately in the centre, between two tooth flanks, without butting against one of these tooth flanks. The user then ensures that the X-position controller is connected to the feeler, while bypassing the computer. As soon as this connection of the X-position controller has been effected and, furthermore, it has been fixed conventionally whether a right or a left tooth flank is to be scanned, the feeler can control the X-drive itself.

This means that the probe approaches the selected tooth flank automatically and stops the X-drive as soon as it has butted against the tooth flank and has been thereby deflected by the predetermined amount. If the user now controls the Y-slide manually in the one or other direction, the feeler automatically follows the X-slide in the positive or negative X-direction so that the deflection of the probe is maintained. The user does not therefore need to worry about this deflection and the movement of the X-slide, and can concentrate entirely on the movements of the Y-slide controlled manually by him or on the corresponding movements of the probe.

It is therefore easy for the user to reach the desired root or tip point. As soon as this has been done, the user only needs to ensure, for example by pressing a button, that the position data of the probe is stored, so that this data is subsequently recognised by the computer as a limit of the measuring range in succeeding traces of the tooth flanks.

According to another aspect of the invention, there is provided a tooth-flank tester comprising means for carrying out a process for fixing one or both limits of the measuring range of a feeler comprising a deflectable probe, wherein the feeler is arranged on a crossslide arrangement having an X-slide movable in the direction of the tooth width of a test piece and a Y-slide movable in the direction of the tooth depth, and X- and Y-drives with respective X- and Y-servomotors, and respective position indicators and position controllers for each of said slides, both drives being controllable optionally manually or by a program-controlled computer which processes signals from the position indicators and also signals transmitted from the feeler itself in accordance with the deflection of its probe and which interrupts the program cycle when the deflection exceeds a predetermined amount, and in which a memory for the position data of a tooth tip point and of a tooth root point as limits of the measuring range to be covered by the feeler is connected to the computer, wherein the X-position controller is connectable optionally to the computer or to the feeler by means of a changeover switch for the process of moving the probe to the tooth tip point and/or the tooth root point of a tooth flank of the test piece for the position data obtained there to be stored.

An embodiment of the invention is illustrated by way of example in the accompanying drawings, wherein:

Fig. 1 is a schematic view of a tooth-flank tester according to the invention with a block diagram of its associated control means, and

Figs. 2a to 2d show a computer programme for automatically carrying out the process according to the invention with the tooth-flank tester of Fig. 1.

Figure 1 illustrates a left tooth flank 10 and a right tooth flank 10′ of a gear toothing which is to be tested. On one of these flanks, position data of a tooth root point 10f and of a tooth tip point 10k are fixed as limits of a measuring range M and are stored.

The tooth-flank tester illustrated has a guide 12x which extends in a direction X tangential to the toothing and is therefore designated as X-guide. Guided on the X-guide 12x is an X-slide 14x which has a graduated scale 16x and is displaceable by an X-drive motor 18x acting through a threaded spindle 20x. Arranged on the X-guide 12x is a position indicator 22x which is connected to a position controller 26x via a counter 24x. Arranged on the X-slide 14x is a Y-guide 12y which extends in the direction of the arrow Y radially in respect of the toothing to be tested, that is to say, at a right-angle to the X-guide 12x, and guides a Y-slide 14y which has a scale 16y and which is displaceable by a Y-drive motor 18y acting through a threaded spindle 20y. For the scale 16y there is a position indicator 22y which is connected to a Y-position controller 26y via a counter 24y.

Arranged on the Y-slide 14y is a feeler 28 which has a deflectable, spherical-tip probe 30.

The counters 24x and 24y as well as the feeler 28 are connected to a computer 32 provided with a memory 34 for data and programs. The memory 34 contains, among other things, storage locations 34f and 34k for the position data which are supplied by the position indicators 22x and 22y when the probe 30 rests against the root point 10f or the tip point 10k respectively and is thereby deflected by a predetermined amount. The computer 32 is connected directly to the Y-position controller 26y which controls the operation of the Y-drive 18y. For connecting the X-position controller 26x optionally to the computer 32 or to the feeler 28 there is provided in this example of the invention a changeover switch which is, in its turn, connected to and controllable via the computer 32.

Finally, Fig. 1 shows a switchboard 38 which has the following keys connected to the computer 32:

Key YF for the instruction to store the position of the Y-slide as ordinate of the tooth root point 10f.

Key YK for the instruction to store the position of the Y-slide as ordinate of the tooth tip point 10k.

Key TK for the instruction to bring the changeover switch out of the position illustrated to Fig. 1 into the position in which the signals of the feeler 28 are supplied to the X-position controller 26x whilst bypassing the computer 32.

Key LF for the instruction to scan the left tooth flank 10.

Key RF for the instruction to scan the right tooth flank 10'.

Key Q acknowledgement key.

Key CLR clearing key.

Keys ±X for manually controlled movement of the X-slide 14x in the direction ±X.

Keys ±Y for manually controlled movement of the Y-slide 14y in the direction ±Y.

In the example of the operation of the process to fix the tooth tip and tooth root limits of the sensing range of the feeler 28 in accordance with the process flow charts of Figs. 2a-2d, at the start the computer-controlled sequence automatically selects the right-hand flank for the limit-fixing movements (first operation in Fig. 2a), switches the X-axis movement to computer control and clears the tooth tip point and root point storage locations SYK and SYF at 34k and 34f, as is indicated by operation of the lamps YFL, YFK of the keys YF, YL.

The acknowledgement lamp QL, previously lit, switches off, and as the X-slide is not then under feeler control, the user by pressing either the LF or the RF key sets the direction and value of the feeler bias force. The sequence moves directly to a point at the beginning of Fig. 2b and the user can employ the ±X keys and ±Y keys to introduce the probe 30 into the approximate central region of the space between two adjacent tooth flanks of the test piece.

The user now operates the key TK, as is shown at the beginning of Fig. 2c, to put the probe "in range" and/or to confirm that it is "in-range", i.e. that it is in contact with the selected tooth flank with a deflection determined by the pre-set bias.

The process sequence now passes directly through 3 at the beginning of Fig. 2d, to point B on Fig. 2a. The X-slide having been put under feeler control, the next operations are shown in Fig. 2b where the user, by further operation of the ±Y keys, controls the Y-slide manually through the computer to move the probe to the tip and root point limits, and in Fig. 2c where these limits are read and stored in the computer store. The sequence is completed and the apparatus is left in readiness for a tooth flank test by the user depressing the acknowledgement key Q, whereupon the flashing of the lamp QL is extinguished and the testing process can be started, employing the tip and root limits that have been fixed.

The flow diagram also illustrates a number of checks and precautions against misuse and malfunction that will not be described in further detail.

Claims

1. Process for fixing one or both limits of a measuring range of a tooth-flank tester, in which a feeler comprising a deflectable probe is arranged on a cross-slide arrangement having an X-slide movable in the direction of the tooth width of a test piece and a Y-slide movable in the direction of the tooth depth, and X- and Y-drives with respective X- and Y-servomotors, and respective position indicators and position controllers for each of said slides, both drives being controllable optionally manually or by a program-controlled computer which processes signals from the position indicators and also signals transmitted from the feeler itself in accordance with the deflection of its probe and which interrupts the program cycle when the deflection exceeds a predetermined amount, and in which a memory for the position data of a tooth tip point and of a tooth root point as limits of the measuring range to be covered by the probe is connected to the computer, for the fixing of said limit(s) the probe being moved to any desired point between and spaced from two adjacent tooth flanks of the test piece, the X-position controller being then connected to the feeler, while bypassing the computer, the probe being brought to rest against a point of one of these flanks by means of a movement of the X-slide controlled by the feeler and being thereby deflected by the predetermined amount and, with the X-slide continuing to be controlled by the feeler itself, the probe being then moved, by manual control of the Y-slide along the tooth flank to the tooth tip point and/or the tooth root point and the position data obtained there being stored to fix said limit(s).

2. Tooth-flank tester comprising means for carrying out a process for fixing one or both limits of the measuring range of a feeler comprising a deflectable probe, wherein the feeler is arranged on a cross-slide arrangement having an X-slide movable in the direction of the tooth width of a test piece and a Y-slide movable in the direction of the tooth depth, and X- and Y-drives with respective X and Y-servomotors, and respective position indicators and position controllers for each of said slides, both drives being controllable optionally manually or by a program-controlled computer which processes signals from the position indicators and also signals transmitted from the feeler itself in accordance with the deflection of its probe and which interrupts the program cycle when the deflection exceeds a predetermined amount, and in which a memory for the position data of a tooth tip point and of a tooth root point as limits of the measuring range to be covered by the feeler is connected to the computer, wherein the X-position controller is

connectible optionally to the computer or to the feeler by means of a changeover switch for the process of moving the probe to the tooth tip point and/or the tooth root point of a tooth flank of the test piece for the position data obtained there to be stored.

3. Process for fixing one or both limits of a measuring range of a tooth-flank tester, substantially as described herein with reference tc the accompanying drawings.

4. Tooth flank tester comprising means for fixing one or both limits of a measuring range of a feeler of the tester, constructed and arranged for use and operation substantially as described herein with reference to the accompanying drawings.

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