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# DESIGN OF SIMPLE TOUCH PROBE FOR CNC MACHINE TOOLS

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## تصميم مجس تلامس بسيط للماكينات ذات التحكم الرقمى

ملخص :

كان للتطور العصرى فى ماكينات القطع والتشغيل ذات التحكم الرقمى متطلباته واحتياجاته. ولقد ادى هذا التطور الى ظهور تطور فى الاجهزه والمعدات المستخدمه على هذه الماكينات لما لها من تأثير على دقه المشغولات على هذه النوعيه من الماكينات ولما لها من دور فى حصر واقلال مصادر الخطأ فى التشغيل ومن اهم هذه الاجهـــزه والمعدات استخدام المجسات المختلفه ومنها مجس التلامس الذى يستخدم فى اكثر من عمليه هانه.

وكان هدف هذا البحث هو تصميم وتنفيذ مجس تلامس بسيط يمكن تركيبه بسهوله على المخارط وماكينـــات القطع والتشغيل المختلفه حتى يستخدم فى كل من :

١ـ تحديد نقاط التلامس بين الشغله واداه القطع
٢ـ تحديد وحساب مقدار الترحيل بين عدد القطع على نفس الماكينه
٣ـ الاستباط وحساب عمر اداه القطع
٤ـ قياس وضبط ابعاد المشغولات على الماكينات

ولقد تم تركيب المجس المصمم على مخرطه قطع ذات تحم رقمى وتمت تجربته فى تحقيق التطبيقات سابقـــه الذكر وثبتت كفائته واهميته لهذه الماكينات.

ومن اهم مميزات المجس سهوله تنفيذه لفكرته البسيطه فى التصميم وكفاءه ادائه على مايكنات القطع ذات التحكم الرقمى مما يساعد على مد استخداماته فى مجالات اخرى.

*ABSTRACT*

*There has been a tremendous increase in the scope of CNC machine tools. This increase has lead to the development of special instruments, which are used to increase the accuracy of the final products and to eliminate the sources of errors in some operations on CNC machine tools, such as "touch off, tool setting, tool wear detection and checking the position of the production". These instruments are called sensors.*

*The aim of this work is to design and fabricate an electric sensor which could be mounted on any machine tool. This sensor and its different styli were applied to cover various applications, such as; Touch off and tool setting, Determination of tool offset, Detection of tool wear, Checking the dimension of the production.*

*The sensor is mounted on a Slant Bed CNC Lathe in different location (chuck, turret and tailstock) to test its capabilites. The obtained results insure the importance of such prope to improve the performance of CNC machine tools. This achievement increases the area of applications of this sensor "Touch Prope" to be used in industrial robotics and other automated manufacturing systems.*

**INTRODUCTION**

Sensors are defined as devices, which detect a certain characteristic of a product (Position, temp.... etc.), as a mean of controlling that characteristic to achieve high accuracy [1,2].

High precision in manufacturing and thus in machining, is essential for the manufacture of many advanced products of strategic importance in international competitiveness. Many new products now demand sub-micron machining accuracies and increasingly, many are forcing the development of machines capable of providing precision in the nanometer region. The use of sensors in NC machines is the tool for raising the precision in machining, hence the precision of the manufactured products. The result was the first touch trigger probe which is capable of rapid, accurate inspection with low trigger forces. The use of modern sensor will play a significant role in the tough competition of marketing. The automation of production processes is advancing ceaselessly. The demands placed on sensors are naturally rising in line with this. To succeed in solving the technical problems of tomorrow and beyond, we need highly-developed sensor technology.

Sensors can be classified as in Fig. (1) according to the design concept and the application used in [ 3 ]. The aim of this work is concentrated on the "Touch Sensors" which could be classified under Tactile (contact) sensors.

It all started with Rolls-Royce engines for Anglo-French Concord. A unique solution was required for accurate pipe measurement.

**Touch sensors:**

These are called "tactile sensors" and are devices which indicate contact between themselves and some other solid object without regard to the magnitude of the contacting force.

The touch trigger probe is a precision omnidirectional triggering device consisting of a probe, a probe head, and a variety of styli to contact the workpieces. The body style may be chosen for mounting on the spindle of a machining center, on a lathe turret and for mounting on the machine bed.

An extremely small deflection. of the order of one micrometer, is required to trigger the probe. The stylus force necessary to cause this deflection is adjustable, and may be set

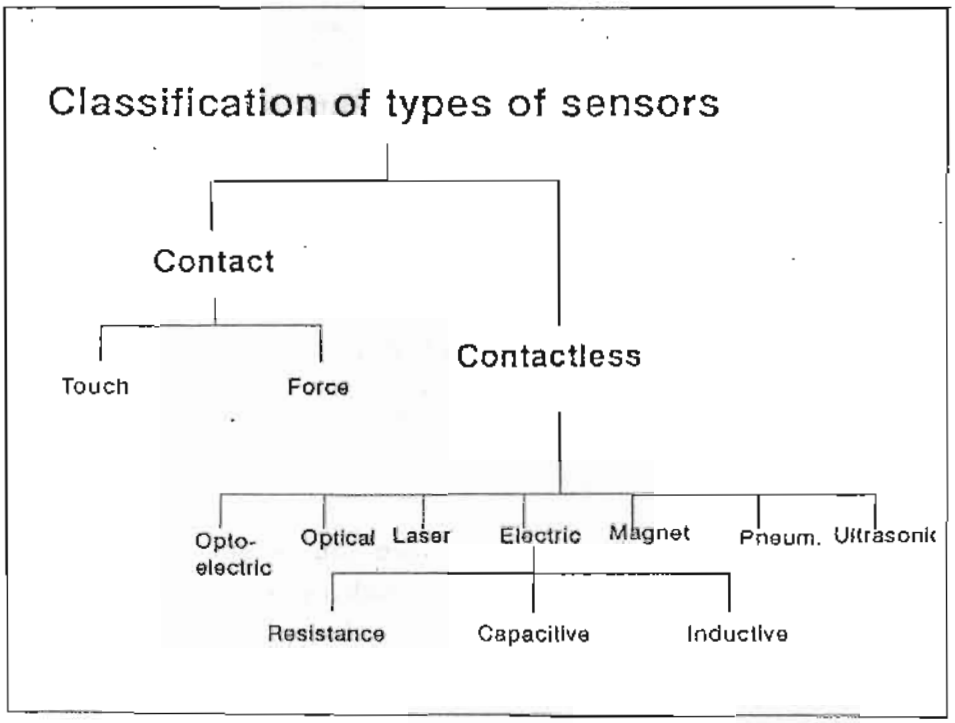



Fig.(1) Classification of Sensors.

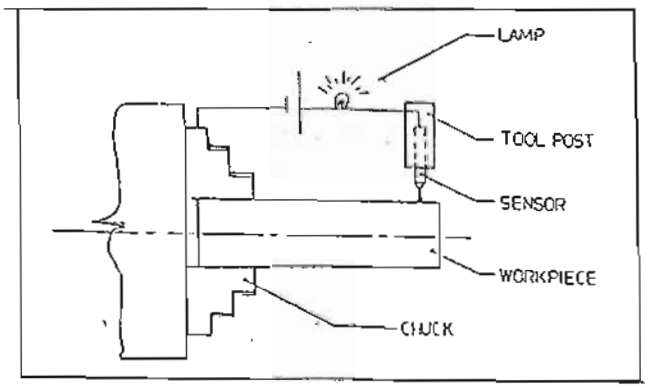



Fig.(2) Operational Principle of the Touch Sensor.

as low as 20 grams [4]. A generous overtravel permits the stylus to deflect after contact, without damage. The stylus returns to its datum or equilibrium position when contact ends.

From the previous analysis one may conclude that the aim of this work is to construct and fabricate a touch sensor based on the simple principle, illustrated in the following paragraphs, to be mounted early on a slant Bed CNC lathe of 8-stations turret head. The sensor is to be designed with different styli and shanks to suite the different applications not only on lathes but also to be suitable for vertical milling Machines.

The sensor is used in different applications as mentioned before.

**Operational Principle:**

Upon touching the workpiece an electrical circuit is completed through the sensor/machine/workpiece and a red indicator light illuminates. At the point where this line flickers, indicating point of contact. a digital read out of the position is given on the monitor of the CNC machine to identify the exact position of contact between the sensor and workpiece as shown in Fig. (2).

**Considerations for Design and Fabrication**

Fig. (3) shows a general view of the probe and its main components, with the possibility for mounting different styli and changing the shanks to suite the mounting system on any machine tool. The design features for such sensors [1,4,6] concerning its function are considered.

All styli have a threaded end allowing their interchange for specific tasks. Most styli can be used on the probe using an adaptor. Styli have the ability to be deflected in case of overtravel beyond the contact position, for quick probing, without stylus damage. Essentially, styli are fabricated in four shapes (Ball, Square, disc and pin types) to cover the expected applications as shown in Fig. (3.b).

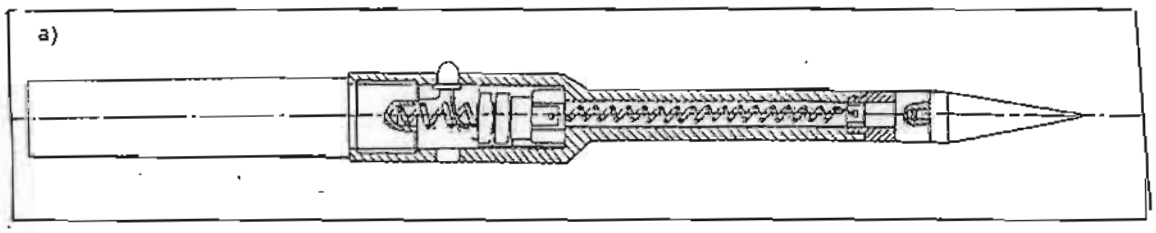
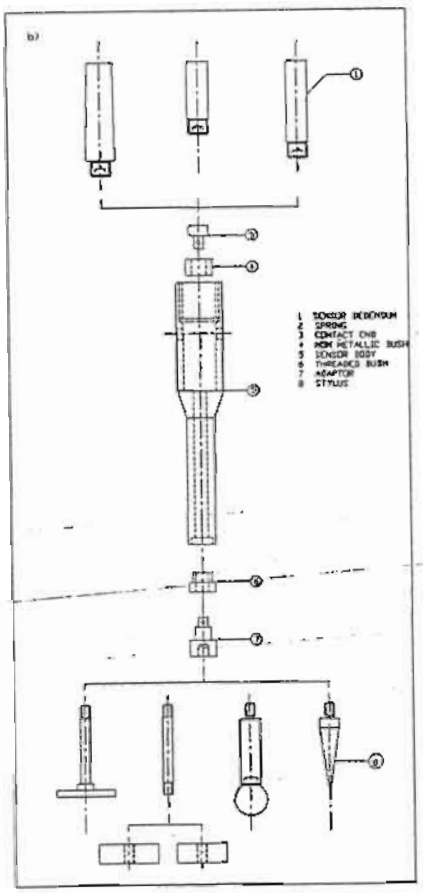
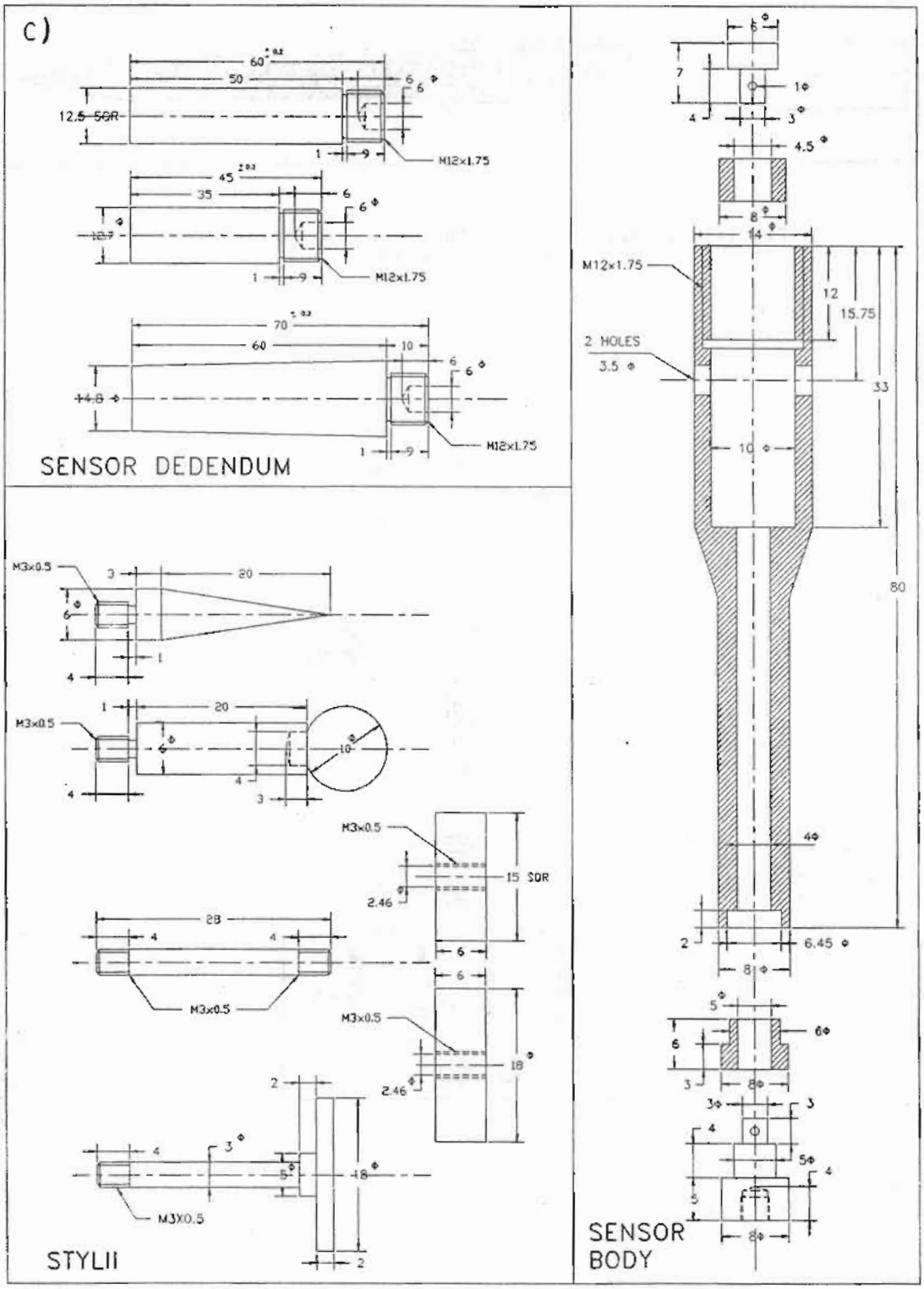



Fig.(3) General view for the designed Touch Sensor and its components.




C)
60
50
12.5 SQR
M12x1.75
45
35
M12x1.75
70
60
10
M12x1.75
SENSOR DEDENDUM
M3x0.5
20
M3x0.5
20
M3x0.5
15 SDR
2.46
28
M3x0.5
M3x0.5
18
2.46
M3X0.5
STYLII
M12x1.75
2 HOLES
3.5
12
15.75
33
80
10
4
6.45
SENSOR
BODY

**Applications**

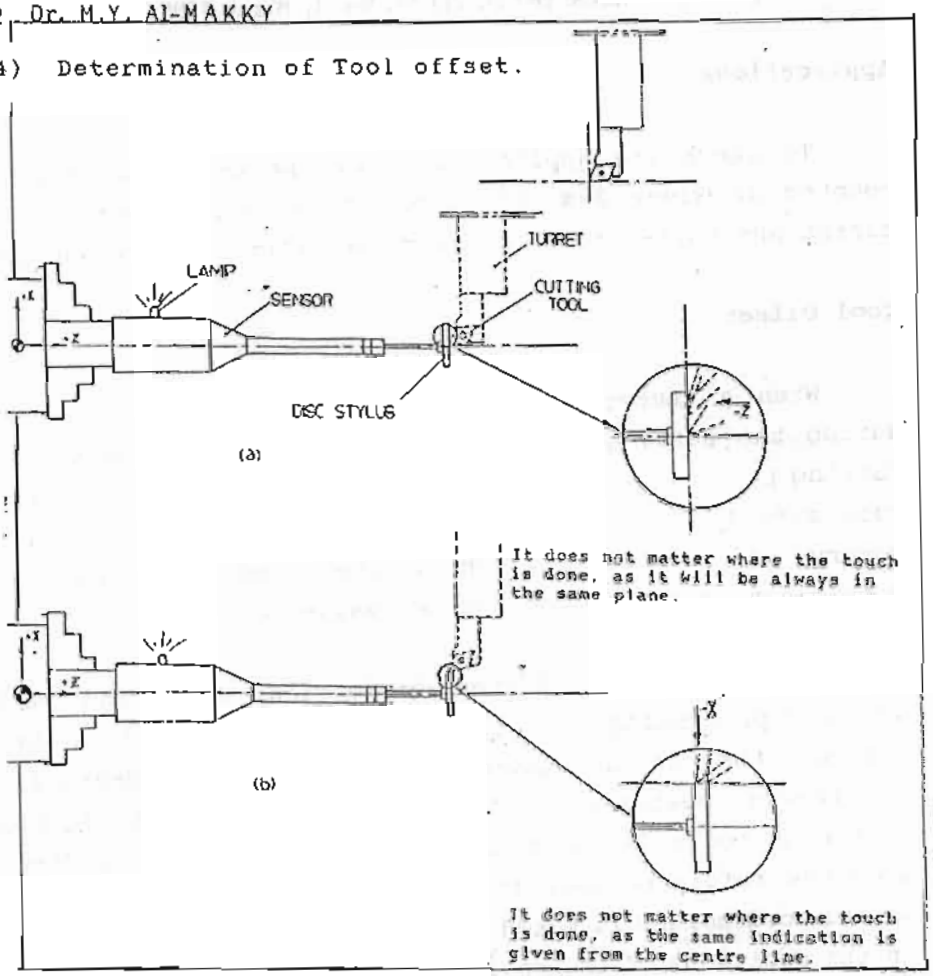
To check the applicability of the designed probe, it is mounted on Slant Bed CNC Lathe in different position (chuck, turret and tail-stock) to cover the practical applications.

**Tool Offset**

When a number of tools are being used, it is necessary during the setting up stage to determine the position of the cutting point of each tool in relation to the zero datums of the work such that the tool offsets are sensed and stored in the memory of the control unit. The sensor is used in the determination of the tool offset value.

Tools can be of different geometries, shape, and the length of tools protruding from the tool post can vary. It is therefore obvious, that as the centre line of the tool holder will be at a different position on the machine when the cutting point of different tools is in contact with the same part of the work. When the reference tool is mounted, the position of the centre of the tool holder is taken as the check position. The difference in the positions of the tool nose for different tools is referred to as the tool offset and it will vary from one tool to another. When a number of tools are being used, it is necessary during the setting up stage to determine the position of the cutting point of each tool in relation to the zero datums of the work in order that the tool offsets are sensed and stored in the memory of the control unit. The sensor is mounted on the chuck. The touch off operation using a disc stylus can be performed in the two directions X and Z for the three mounted tools on the turret head, as shown in Fig. (4). The obtained results from this test are tabulated in Fig. (5) to show the tool file for the offset calculations.

Fig.(4) Determination of Tool offset.



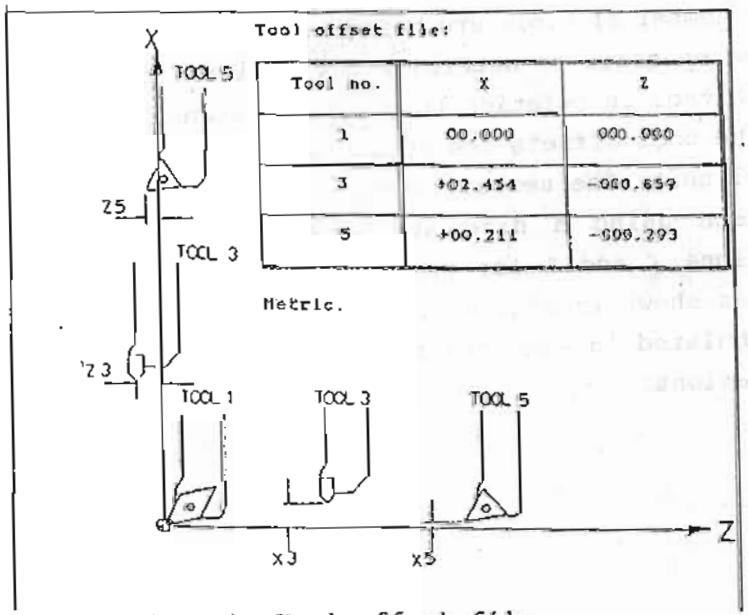




Fig.(5) Tool offset file.

**Detection of tool wear**

The sensor can be used for the determination of tool wear (wear in nose and flank ). The sensor is mounted in the tail stock using a disc stylus. The cutting tools are moved to perform the touch.off operation with the sensor before machining and after machining as shown in Fig. (6.a) and Fig. (6.b). The exact coordinate values in X and Z direction were recorded from the control unit. The difference in each direction before; and after machining, can be considered as an indicating parameter for tool wear.

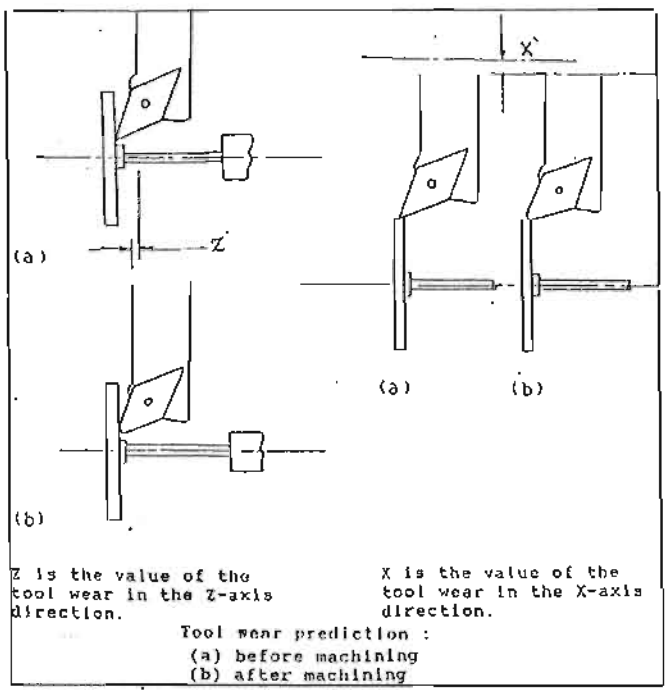



Fig.(6) Detection of Tool wear.

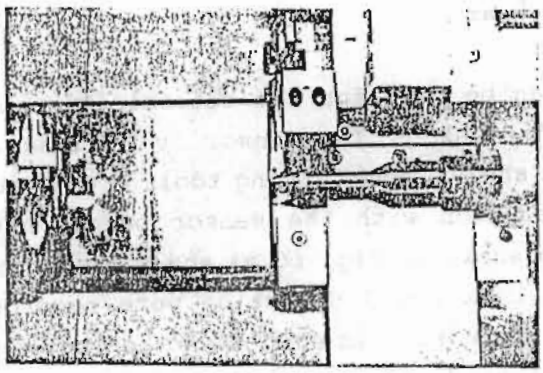


Fig.(6)

**Dimensional measurements**

The sensor is used for measuring different dimensions of workpieces. By mounting the sensor on the turret and using a ball stylus.

The turret is moved in the radial direction till the LED illuminates -giving the indication that the sensor is touching-, and the reading is taken from the control unit. This step is repeated in the X or Z direction and by recording the coordinate values in X or Z directions. The required dimension of any component is obtained within the degree of accuracy of the control unit. See Fig. (7)

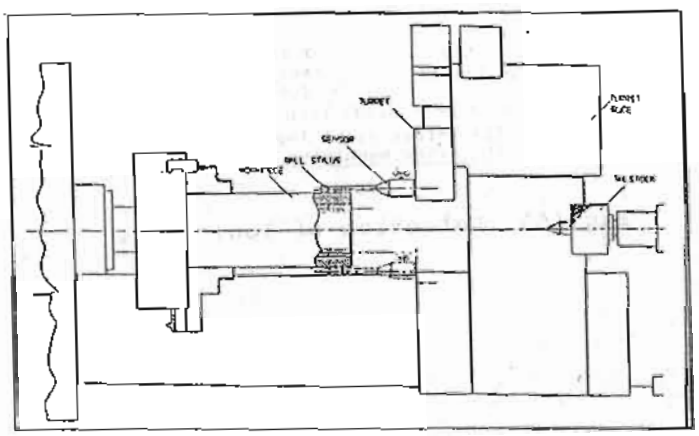


Fig.(7) Dimensional measurements.

**Concluding Remarks**

- From the present work, it is clear that the simple principle of the designed sensor was successfully applied in the following practical, industrial applications:
  1. Tool setting and tool offset and touch off process.
  2. Detection of tool wear.
- The sensors can be used as a measuring device to determine the exact dimension and position of any test specimen on the machine tool depending on the digitized read out of the NC system.
- As a further proposal for extending and developing this design. The touch trigger probe may be connected electrically by cable to the interface unit. Whenever the stylus touches the specimen in any direction the probe sends a signal to the M/C controller where this position of the probe is recorded and the forward motion of the machine component is stopped, hence the current coordinates of the point at contact are known. The proposed line sketch for this application is shown in Fig. (8).

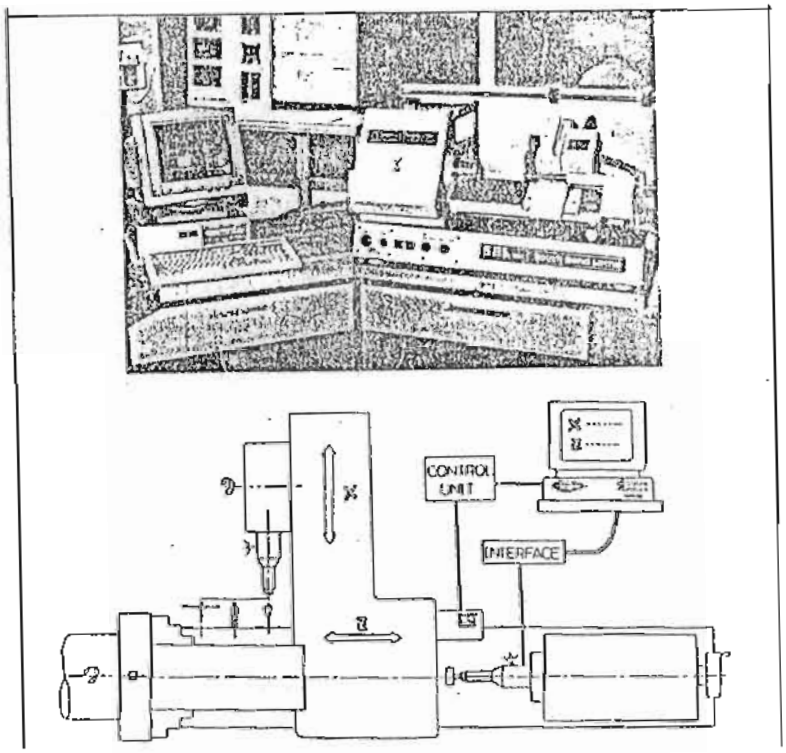



Fig.(8) Interfacing the Touch Sensor with CNC System.

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