PATENT SPECIFICATION

715,477

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COMPLETE SPECIFICATION

A Computing Device for Calculations relating to Machine Tools

I, ROGER CHARLES MARIE EMILE GRANDADAM, a Citizen of French Republic, of 11, Rue de Vaucouleurs, Vandoeuvre, Meurthe et Moselle, France, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed to be particularly described in and by the following statement:—

The present invention relates to a computing device which by determining directly and precisely the allotment of operational tasks to various machine tools and their adjustment, enables the highest possible output in a tool room to be obtained.

Generally speaking, the computing device for machine tools according to the present invention makes possible the quick and direct solution of all normally occurring problems of machining having regard to the proper utilisation of the tools, to the dynamic characteristics of the machines, and to the flexibility of the work pieces or their mounting.

By "dynamic characteristics" is meant all the factors which relate to the behaviour and the potentialities of the machine for work and characteristics other than dimensional ones. The dynamic characteristics include in particular: the power of the prime mover; the output of the machine at various speeds; the state of wear and tear which may result in a limitation of production due to vibrations caused by play in the component parts; the resistance of the compenents causing limitation of torque; and the ranges of speed and feed of the tool.

The hitherto known devices or slide rules permit the determination of adjustments which have to be carried out on a machine in order to ensure the proper utilisation of a single tool. In some of these devices the dynamic characteristics of the machine can only be included in the calculations in an inaccurate and arbitrary manner and without regard to the flexibility of the work pieces or to their mounting. For this reason these slide rules do not make possible the allotment of operational tasks in a scientific manner. The allotment of operational tasks is left to the attention of technicians and depends on their professional knowledge and experience, with the result that the best possible output is never achieved.

[*Price*

The present invention has been developed with the general objects of ensuring the best possible allotment of operational tasks to the various machine tools in a factory; ascertaining the adjustments which have to be made on each machine in order to achieve the operational task in the shortest possible time; ascertaining the nature and quality of the tool which should be used for the given operational task in order to achieve it in the shortest possible time and with the lowest possible wear and tear of the tool, and ascertaining the necessary time for each operation or group of operations for any length of machining.

With these objects in view the device according to the invention comprises a fixed base, an element movably mounted on said base, a group of characteristic curves upon said movable element, a second group of characteristic curves which may be either upon said movable element or upon said fixed base, another characteristic curve formed by the intersecting points of the first two groups of curves, graduated scales for measuring the displacement of the element movable with respect to the fixed base, a slide rule movable with respect to said base and to the movable element and a pointer carried by this rule adapted to be placed in juxtaposition to the characteristic curves.

The word "curve" is used in its graphical sense to mean a line representing an algebraical relationship, *i.e.*, it includes both "curves" and "straight lines" in the geometrical sense.

A device according to the invention has the feature that once it has been adjusted, it suffices to register the data of a problem whereupon the desired results can be read directly; thirty seconds suffice for solving any machining problem, including the time necessary for the adjustment of the device.

Two embodiments of the invention are shown diagrammatically by way of example in the accompanying drawing in which:—

Fig. 1 is a front view of one embodiment of the invention,

Fig. 2 is a sectional view along the line II—II in Fig. 1,

Fig. 3 is a view similar to that in Fig. 1, of an alternative form of the invention, and

Figs. 4 and 5 are sectional views along the lines IV—IV and V—V in Fig. 3 respectively.

As shown in Figs. 1 and 2 of the drawing, the device comprises a flat fixed base plate A of any suitable shape, which is provided with a logarithmic scale 1 representing "depth of cut" and with another scale 2 representing "co-efficient R2." Scale 1 is an arc, with centre at the point C2, and scale 2 is an arc with centre at C1.

R2 is a co-efficient which depends upon the metal being machined, the tool being used, and the conditions of machining (angle of attack of the tool, permissible duration of cut between sharpenings). For different values of these variables, R2 can be ascertained empirically, and a table giving values of R2 for different values of the variables is on the back of the apparatus. Since R2 has no absolute meaning, the scale of R2 may be linear or logarithmic or of any other form desired, but since it is used in conjunction with a logarithmic scale, it may be regarded as being logarithmic.

On the base plate there is mounted a movable element in the form of a disc B rotatable about its centre C_1 by means of a lever 3 or by any other means capable of imparting rotary motion thereto. This disc is provided with a scale 4 composed of a series of curves each of which represents a particular value of "feed per revolution of the tool." This scale is so drawn that if in a problem the value of "feed per revolution" is taken from this scale, the solution found will be the best possible for the tool being used. Such a solution is independent of R2, and therefore the curves of "feed per revolution" are concentric with scale 2.

The disc B is further provided with a second scale 5, also composed of curves representing "feed per revolution." This scale is so drawn as to give the best possible solution to a problem for the machine being used. A curve 6 connects points of intersection of lines of equal feed on scales 4 and 5, and therefore scale 6 gives a solution to a problem which is the best possible for both tool and machine. Scale 5 also carries markings (not shown) along the curves of feed, representing the flexibility of the tools or mountings. The disc B is further provided with a logarithmic scale 7 representing "productive capacity of the machine." This is a characteristic of the machine being used, depending upon its power, its state of repair, and the frictional resistance of its components, and it is best determined experimentally for each machine. Scale 7 is concentric with disc B and is read against the appropriate value of R2 on scale 2.

Above the disc B is disposed a slide rule C comprising a base 8 rotatable around a pivot at C^2 which is placed eccentrically with regard to the centre C_1 of the disc B, the amount and the direction of the eccentricity being such as to make possible the solving of the problems.

The frame 8 of the slide rule carries a pointer or indicator 9 for reading "depth of cut" on scale 1 and one of its longitudinal sides is provided with a scale 10, representing "co-efficients R_1" R_1 is a co-efficient which depends upon the same variables as does co-efficient R_2, and values of R_1 for different values of the variables are given by a table on the back of the apparatus. For the same reason as scale 2 of R_2, this scale may be either linear or logarithmetic, but since it is used in conjunction with a logarithmetic scale, it may be regarded as being logarithmic.

A rule 11 is slidably mounted in the frame 8, and is provided on one of its longitudinal sides with a reciprocal logarithmic scale 12 representing "speeds" in revolutions per minute. This scale is set relative to the appropriate value of R_1 on scale 10 by means of a datum mark 12*a*.

On its other longitudinal side rule 11 is provided with a logarithmic scale 14 representing "machining time."

Within the rule 11 there is slidably mounted a small rule 15 having a pointer or indicator 16 for indicating any point on the movable disc B.

The small rule 15 is provided along one of its longitudinal sides with a logarithmetic scale 18 representing "feed per revolution of the tool," and along its other longitudinal side with a logarithmetic scale 17 which in problems in which the whole apparatus is used, represents the diameter of the tool or workpiece, and in problems in which the slide rule alone is used, represents the depth of cut.

By means of the knob 19 the small rule 15 can easily be moved and the assembly C rotated.

The glass cursor 20 is provided with two datum marks and is slidable along the rule.

The rear surface of the device is provided with a table of the co-efficients R_1 and R_2 with cross-references to corresponding figures on the scales 10 and 2 for the utilisation of the tools having regard to the machining of various materials for cutting periods of the tools. This table contains also recommendations for the adjustment of the device for machining semi-rigid and flexible work pieces with overhanging mountings or assemblies.

When the problems are being solved, the whole of the apparatus may be brought into operation, or the slide rule may be used by itself.

The slide rule is used by itself in problems on the formula:—

Time of machining feed per revolution speed of rotation = Depth of cut. The time of machining is read off scale 14, the feed per revolution of scale 18, the speed of rotation off scale 12, and the depth of cut off scale 17.

The cursor carries two datum lines, such that if one gives the time of an operation on scale 14 in hundredths of an hour, the other gives the time in minutes, *i.e.,* the distance between the datum lines represents a multiplication by six tenths on scale 14.

The speed of cutting is given by the depth of cut in a machining time of one minute, and to avoid the use of the cursor in this calculation, scale 12 carries a datum mark 13 which is in the position of one minute on scale 14, so allowing speed in metres per minute to be read directly off scale 17.

Scales 14, 18 and depth of cut on scale 17 are only used in problems of the above type, solvable by the slide rule alone.

The whole apparatus is used in problems concerned with the variables,

Depth of cut	– scale	1
R_2	„	2
Feed per revolution ...	„	4, 5, 6
Flexibility of tool or workpiece	„	5
Productive capacity of machine	„	7
R_1	„	10
Cutting speed	„	12
Diameter of tool or workpiece	„	17

Since scale 5, is a two diemensional scale, any calculation in which scale 5 is used represents a solution to two simultaneous equations, the form of these equations depending upon the dimensions of the apparatus, and the functions of the variables used in making the various scales. In this apparatus the two equations are those which connect the variables when the machine is being used to the total extent of its productive capacity.

In scale 4, the lines of equal feed per revolution are concentric with the disc B, and scale 4 is therefore equivalent to a linear scale, and represents the solution to only one equation. This is the equation which connects the variables for proper utilisation of the tools.

Scale 6 is the intersection of scales 4 and 5, and therefore represents a solution to all three equations simultaneously giving the connection between the variables when both machine and tool are used to the best extent, i.e., when the tool and machine are correctly matched to one another.

The following examples of the solution of various problems by means of the device according to the present invention will illustrate the function of the various members and will also enable the advantages of this device to be realised.

Problem I—Allotment of operational tasks. It has to be decided which machine is to be allotted a given operational task in order to ensure that it is carried out within the shortest possible time to permit of the highest possible total output of the factory.

In order to solve this problem, it is necessary to ascertain the dynamic characteristics of the machine required and of the productive power necessary to carry out the machining within the shortest possible time whilst ensuring at the same time proper utilisation of the chosen tools.

Information is required first concerning the dimensions and the qualities of the material of the workpiece.

Secondly it is required to know the quantity of the material to be removed in the machining operation and the quality desired in the finished surface. Accuracy of reading is not required; it depends on the professional skill of the workman and on the precision of the machine which is to be selected amongst the machines possessing the dynamic characteristics determined by the solution of the given problem. The same applies to the dimensional characteristics of the machine.

To solve the problem, it is first necessary to read off from the table on the rear face of the device the minimum co-efficients R_1 and R_2 for the machining of the material of the workpiece.

The co-efficient R_1 on the threefold rule is now transferred by sliding the rule 8 until the datum-mark 12*a* is opposite the figure on the scale 10 which corresponds to R_1. The value of the co-efficient R_2 is mentally noted. The table on the rear of the device is now referred to and the section corresponding to the adjustment of the device in regard to the flexibility of the workpiece is discovered: this ratio is indicated by the dimensions of the workpiece which characterise its flexibility, *e.g.,* in the case of a shaft the ratio of its diameter to its length.

The indicator 9 is now set against a figure of the scale 1 so that it registers a particular depth of cut, such that its product with the feed to be registered, as explained later, indicates the section of the device to be read as indicated.

The small rule 15 is now moved, and the disc B is rotated in such a manner that the indicator 16 points to the selected curve of feed to indicate the datum-mark ascertained on the scale 5 as corresponding to the degree of flexibility of the workpiece.

The device is now adjusted for solving the particular given problem. Each of the figures on the scales identified by the indicator 16 represents one possible solution of the given problem of machining.

Transfer the value of the depth of the material to be removed from the smallest diameter of the piece by rotating the assembly C in such a way as to bring the indicator 9 opposite the chosen figure on the scale 1; and slide the small rule 15 so as to bring the indicator on to the curve 6.

The solution of the given problem can now be read off as follows:—

(*a*) Opposite the figure R^2 on scale 2, the necessary and sufficient productive power of the machine being indicated on the scale 7 of the disc.

(*b*) As indicated on small rule 16, the feed which the machine should be able to make.

(*c*) Opposite the minimum diameter of the workpiece transferred to the scale 17 of the small rule, the maximum speed of the machine, as read off on the scale 12.

There are two possible alternatives. When the depth of cut has been registered as explained and the small rule 15 has been moved, it may happen that the indicator 16 does not intersect the curve 6.

First alternative: The indicator of the small rule 16 rests on the scale 4. This means that it is impossible to find the best possible solution of the given problem if a tool corresponding to the chosen co-efficients R_1 and R^2 is used, it being necessary to choose some other tool, as explained in connection with Problem 3, or else to choose some other cutting period of the tool during the machining.

Second alternative: The indicator 16 rests on the scale 5 but does not intersect the curve 6. This means that the depth of cut is too large. Any one of the solutions ascertained on this scale however is possible and solves the problem. In order to achieve an efficient cut it is however advisable to choose two or three different depths of cut each of which is determined by the indicator 16 on the curve 6.

In any one of the above-mentioned alternatives, the solution arrived at and indicating the characteristics of the machine is the only proper solution of the given problem, having regard to the desired quality of the surface finish of the workpiece.

Problem 2—Determination of the adjustments which it is necessary to make to a machine in order to accomplish the machining operation within the shortest possible time.

Information is required concerning the productive capacity of the machine, its range of speeds, and its range of feeds.

Also the dimensions and material of the workpiece must be known.

The tool which has the qualities needed for the machining of the material, is characterised by the length of time required to make a cut.

To solve the problem it is necessary to ascertain all possible combinations of the following factors: namely, speed, depth of cut, and feed, which would make possible the solution of the problem. Amongst these solutions it will be necessary carefully to make a choice which should be influenced by technical aspects of the various machining operations, having regard to the quantity of material to be removed and the desired quality of surface finish, the possible limits of the range of the machine, and the like.

First ascertain on the rear of the device the co-efficients R_1 and R_2 which correspond to the tool chosen for the machining of the material and for the duration of the cut desired.

Obtain on the threefold rule the co-efficient R_1 in the above described manner, and obtain the productive capacity of the machine on the scale 2, opposite the respective value of R_2, by rotating the disc B.

The device is now set. Rotate the threefold rule and slide the small rule 15 so that the indicator 16 describes a trajectory of the curve 6. Any one of the points on this curve pointed out by the indicator 16 gives one possible solution of the problem. For each of these points one can ascertain (*a*) the permissible depth of the cut, on the scale 1 as indicated by the datum-mark 9; (*b*) the feed as pointed by the indicator 16 of the small rule; (*c*) the speed of rotation on the scale 12 as a function of the diameter of the workpiece or of the tools. Furthermore, the speed of the cut in metres per minute on the scale 17 is indicated by the datum-mark 13.

If an accurate value for one of these four values is chosen, the other three values can be ascertained, and represent the only possible combination for the complete solution of the given problem.

If for technical reasons two of these values are accurately chosen, the other two values can likewise be ascertained, but the following three circumstances have to be taken into consideration:—

(*a*) If the indicator 16 rests on the curve 6, the solution obtained is an optimum, and is the only possible one for the complete solution of the problem.

(*b*) If the indicator 16 rests on the scale 4, the choice of the tool made is correct, but the machine will not be utilised to its full capacity. In this case it is advisable to find a tool of a superior quality or one which can perform under more exacting conditions of work (Problem 3).

(c) If the indicator 16 rests on the scale 5, the machine will be utilised to the full extent of its capacity, but the tool will not be utilised to the full extent anticipated of its possible capacity. Notwithstanding this circumstance however the solution found will solve the problem of the minimum possible time for the machining of the workpiece and of the possible maximum utilisation of the capacity of the whole assembly of machines, provided that the operational tasks have been allotted in advance as indicated in connection with Problem 1. In this case the explanations given in connection with Problem 3 will make it possible to find out if necessary which tool is best adapted to the given conditions of work.

Problem 3—It is required to ascertain the quality of the tool needed for achieving the required machining in the minimum time and with the minimum wear and tear.

The desired machining is defined for the given quality of the material by the depth of the cut and the feed corresponding to the desired quality of the surface finish. The machining time will be the shortest possible, if the highest possible speed permitted is applied in view of the range of speeds or with regard to the workpiece (flexible pieces, Problem 1).

Solution: The small rule 15 is moved so as to bring the diameter of the pieces or of the tools (scale 17) opposite the highest permissible speed (scale 12). The depth of cut value is ascertained by bringing datum-mark 9 opposite the chosen figure on the scale 1. The rule 11 together with small rule 15 are together moved without changing their relative position, so as to bring the pointer 16 on the curve 6 to the point of the feed required by the quality of the surface, rotating the disc if necessary. The value of the co-efficient R_1 indicated by the datum-mark 12*a* is now read.

By means of the table on the rear of the device, having regard to the quality of the material to be machined, that one of the known tools which promises the solution of the problem is selected, by comparing the available values of the R_1 with the value of the co-efficient R_1 ascertained.

The tool which offers the nearest value of the co-efficient R_1 is the one to be chosen.

Problem 4—It is required to determine the time required for the operation of the machine. The longer datum-mark of the cursor is brought in to coincidence with the value of the speed ascertained in connection with the preceding problems (scale 12). The small ruler 15 is now moved so as to bring the ascertained feed value, as read off the scale 18, underneath the main datum-mark of the cursor. The cursor is now moved so as to bring its longer datum-mark over the length of cut value read on the scale 17.

The length of time of the operation will then be indicated on the scale 14 by the longer datum-mark of the cursor in hundredths of an hour, and by the smaller datum-mark of the cursor in minutes.

In the calibration of the device prior to attempting the solution of these problems, the values characterising the limit of operations should be entered on the device and the value of the output of each machine should be ascertained, which value will then be used for all the calculations.

Alternatives.—The device according to the present invention may be modified alternatively as follows:—

I. By disposing the scale 4 on the flat base A in which case the disc B is provided with an opening having the curve 6 as a boundary.

II. By use of cartesian co-ordinates for the solution of the same problems.

In this modification the device is as shown in Figs. 3 and 4 of the accompanying drawing and comprises a frame A which is provided with a logarithmic scale I representing "depths," with a decimal or logarithmic scale 2 representing "co-efficients R_2," and with a guide *g* for the slide B, the latter being provided with a scale 4 consisting of lines extending parallel to the guide *g* and numbered to represent different feeds: this scale 4 represents "correct use of tools."

The second scale 5 represents "total utilisation of the productive capacity of the machine;" its lines are numbered so as to represent different feeds.

The curve 6 connects the points of intersection of the lines of the same feed on the two scales 4 and 5.

The logarithmic scale 7 represents productive capacity.

A threefold slide-rule 8-11-17, similar to that described previously, but arranged for sliding movement instead of being rotatable round a pivot, is mounted on the frame A and is supported along its sides.

The solution of the above-mentioned problems is achieved by means of this alternative device in the same way as discussed previously, the only difference being that rotational movement is here replaced by rectilinear movement.

The device, using cartesian co-ordinates, can be constructed according to the alternative I as above described. In this case the scale 4 is disposed on the frame A and the slide B which is guided in the same way in the guides *g*, is limited by the curve 6 forming its left-hand edge.

Utilisation of the output indicator.

All machining problems arising in connection with any one of the machines used for the removing of material, with the exception of grinding machines, can be solved by means of the present device, with respect to every kind of material which can be machined, and with respect to tools of every conceivable form and composition. The device can be used also in office work for the preparation of the work and calculation of time, by the foremen and by the workmen, in order to ensure the best possible output of the machines and efficient utilisation of the tools.

What I claim is:—

1. A computing device for calculations relating to machine tools comprising a fixed base, an element movably mounted on said base, a group of characteristic curves upon said movable element, a second group of characteristic curves which may be either upon said movable element or upon said fixed base, another characteristic curve formed by the intersecting points of the first two groups of curves, graduated scales for measuring the displacement of the element movable with respect to said base and to the movable element and a pointer carried by this rule adapted to be placed in juxtaposition to the characteristic curves.

2. A device according to Claim 1, wherein the movable element comprises a disc which is rotatably disposed on the fixed base.

3. A device according to Claim 1, wherein the movable element comprises a rectilinearly movable slide.

4. A device according to Claim 2, wherein the rule is rotatably mounted on an axis eccentrically located with respect to the disc.

5. A device according to Claim 1, wherein the slide rule comprises two rules or slides which are movable with respect to each other and to the frame of the rule provided with graduated scales and datum-marks.

6. A device according to Claim 1, wherein the slide rule is provided with two pointers or indicators one of which is carried in the frame of the slide rule and is displaceable along a scale on the fixed base and the other is carried by a slide of the rule and movable along the characteristic curves.

7. A device for determining data relating to machine tools substantially as herein described with reference to the accompanying drawings.

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Fig1

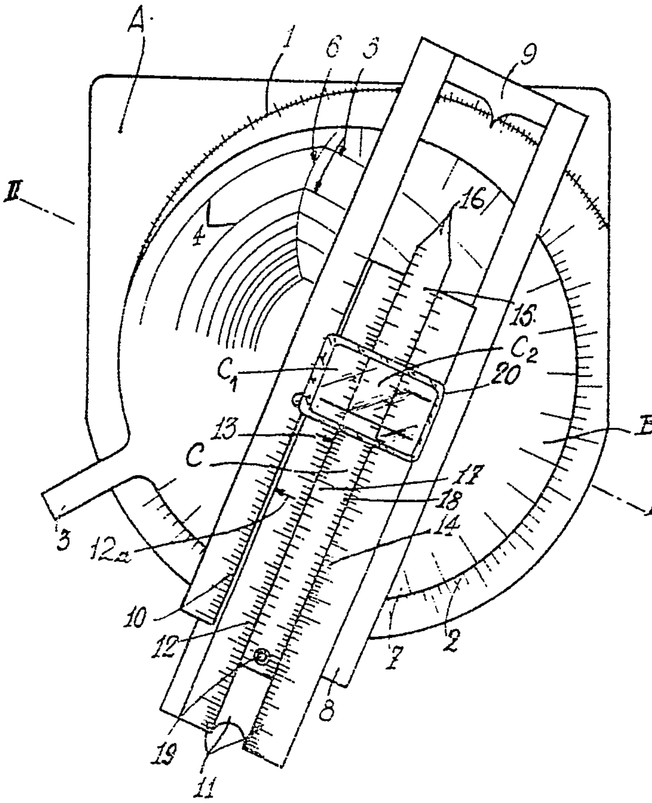
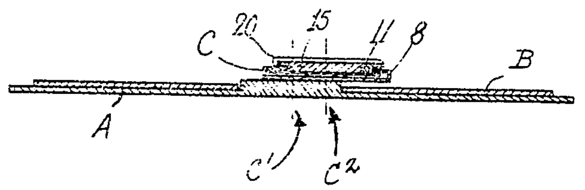

A
1
6
5
9
II
4
16
15
C2
C1
20
13
B
C
17
18
II
3
12a
14
10
12
7
2
8
19
11

Fig2


20
15
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8
C
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A
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C2

715,477 COMPLETE SPECIFICATION
2 SHEETS

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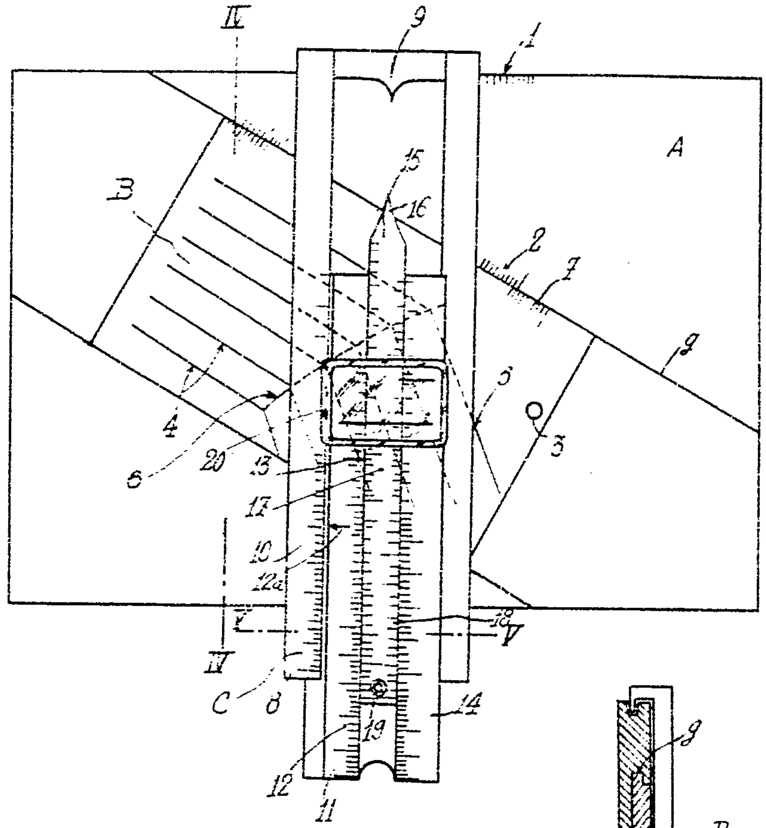
SHEETS 1 & 2

Fig 3



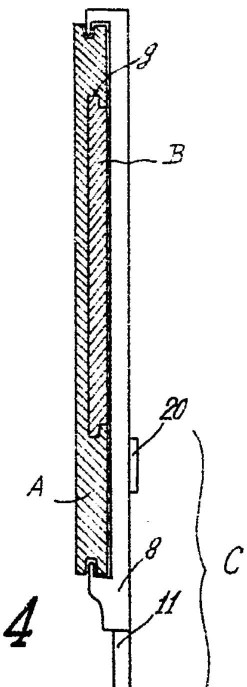
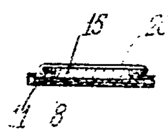


Fig4

Fig5



715,477 COMPLETE SPECIFICATION
2 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

Fig1

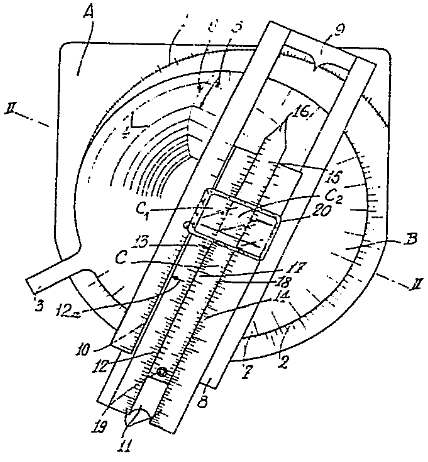


Fig2

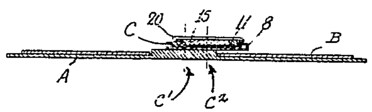


Fig 3

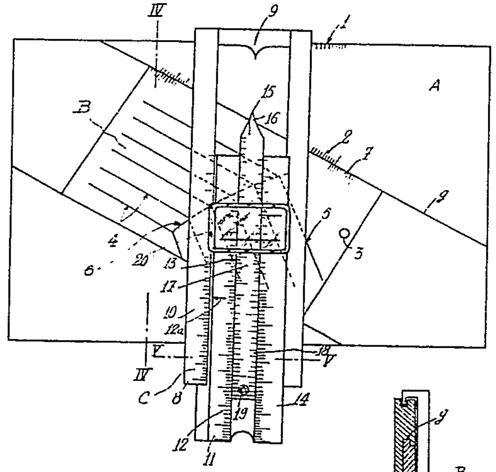
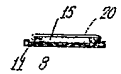


Fig5



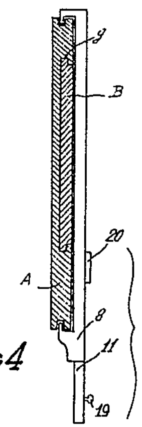


Fig4