368,336

PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in and relating to the Mounting of Pivoted Apparatus, such as Electrical Sound Recording Devices.

We, ALAN DOWER BLUMLEIN, of 57, Earl's Court Square, London, S.W.5, and HERBERT EDWARD HOLMAN, of 64a, The Chase, Clapham Common, London, S.W.4, both British subjects, do hereby declare the nature of this invention to be as follows:-

This invention relates to the mounting of parts of apparatus having motion about a fixed axis and is directed more particularly to the mounting of electrical devices employed for recording sound on wax discs.

In such devices the recording stylus in addition to being subjected to lateral vibratory motion whereby the sound record is made, is usually so mounted that it may have some vertical movement to accommodate for any irregularities in the wax surface and maintain a uniform depth of cut. The inertia of the apparatus in response to such movement naturally has considerable effect upon the accuracy and sensitivity of the recording, and one object of the present invention is to overcome previous inertia difficulties and thereby to improve the accuracy and sensitivity of the apparatus and to extend the working sound-frequency range to which it will responds.

The invention consists in a method of mounting pivoted parts of apparatus whereby the effective inertia against forces tending to move them about the pivotal axis is reduced.

The invention further consists in a method of floating parts of sound-recording apparatus whereby the effective inertia at the stylus point is reduced to a minimum.

The invention also consists in means for carrying into effect the methods indicated in the next two preceding paragraphs comprising knife edges or similar floating devices whereby the floater axis is positioned at a distance *d* from the centre of gravity of the floating member and on the side thereof opposite to the stylus point: where

EQUAT. HERE

K being the radius of gyration of the floating member, in the plane of floating about its centre of gravity; and *l* being the distance between the stylus point and the centre of gravity.

The invention also consists in the provision of means associated with the floating arrangements set out above whereby, should the depth of groove cut by the stylus vary from its normal preset value, the restoring forces on the stylus will be large and will operate quickly. Means are also preferably provided whereby the return movement of the device set up by these restoring forces is substantially deadbeat.

Further features of the invention will become apparent from the following description of one modification thereof, which will be given with particular reference to sound-recording devices disclosed in our co-pending paten application No. 7809/30 (Serial No. 350,998) , but must be understood to have a wide field of application I connection with many other forms of sound-recording devices and other kinds of apparatus I general, and is not therefore limited to use with the particular form of apparatus described.

The apparatus disclosed in our co-pending application No. 7809/30 (Serial No. 350,998) referred to comprises a field system formed of a U-shaped electromagnet (on the arms of which are mounted bulky energising windings), between the poles of which is pivoted a moving coil whereby the recording stylus is operated. Current is induced in the moving coil by windings of another magnetic circuit mounted to intercept the field of the U-shaped electromagnet at right angles. The moving coil thus forms a secondary winding in the actuating magnetic circuit and, being mounted in a magnetic field of great strength, oscillates in a manner suitable for cutting a wax disc. In general the moving coil is pivoted about a vertical axis, while to allow for unevenness of the disc surface movement of the whole device is desired about a horizontal axis; and it will be seen that the association with the field system of another comparatively heavy magnetic circuit, and the necessity of extensive and bulky windings on the field system, render delicate mounting of the device a matter of great importance.

In carrying the present invention into effect in one convenient manner in connection with apparatus described, the whole recording device may be supported in a spectacle plate, preferably of cast aluminium, which may be clamped round the field coil bobbins of the U-shaped electromagnet forming the field system. These bobbins are completely enclosed by aluminum tubes of accurate dimensions which thus form a firm foundation on which the spectacle plate may be clamped. On the outer flat surfaces of the spectacle plate are screwed blocks, preferably of steel, provided with V-shaped notches adapted to rest on knife edges provided on the bracket which carries the device. The spectacle plate is preferably quite light, thus forming a firm holder for the recorder without the addition of any appreciable inertia.

For best results the V-shaped blocks which determine the position of the floating axis must be secured in an optimum position, and it has been found that in order to obtain minimum needle point inertia, the optimum position of the floater axis is not the centre of gravity of the recorder, but a point more remote that this from the sapphire. The optimum point lies on a line drawn through the sapphire point and the centre of gravity of the recorder and at a distance d from the centre of gravity where d is given by

EQUAT. HERE

the symbols having other meanings defined above.

It has been found that in some cases the value of K is small compared with *l*, so that the reduction in sapphire point inertia due to removing the floater axis from the centre of gravity to the optimum point is negligible. Such movement of the floater axis entails the introduction of a spring or other counterbalancing means in order to reduce the excess weight of the recorder on the wax so as to regulate the depth of cut.

Another condition for satisfactory floating has been observed. In order that a reorder may produce a uniform depth of cut in an uneven wax blank, it is necessary that a small increase of depth of cut should produce as large an acceleration as possible of the recorder upwards, or vice versa, so as to restore the correct depth as quickly as possible. This condition is best realised when a line drawing from the sapphire to the axis of floating, subtends an angle of 45° to the wax surface. If, however, a vary uneven blank is being used, the forward movement of the recorder sapphire which under these conditions accompanies a vertical movement, will cause a change of cutting speed. It is advantageous to reduce this angle to less than 45°, in order that this forward movement for a given vertical movement may be reduced. Angles between 30 and 45° are the most advantageous for floating, and a preferred value is 40° between the stylus point floater axis line, and the wax surface.

While, as described above, it is desirable that effective restoring forces hall be brought quickly into play upon displacement of the stylus, it is essential that the return movement of the device shall be substantially dead-beat to avoid any vertical oscillatory action of the stylus on the wax, and to this end suitable damping means are preferably introduced. Such means may, for example, take the form of a dash-pot arranged, or, if desired, adjustable, so that while allowing the recorder to assume normal position as soon as possible after displacement, it nevertheless prevents overshooting. The arrangement may comprise an arm projecting, preferably away from the stylus, horizontally from the spectacle plate, to the end of which arm is secured a flat preferably circular, disc. This disc dips into a cylindrical cup containing any suitable damping fluid such as water, oil, a mixture of oils or of oil with benzine.

Alternatively the dash-pot may be dispensed with and friction damping employed. Such means may comprise a small brake bearing on a cylindrical surface on the spectacle plate coaxial with the floater axis; or the knife edges may be rendered blunt to give a mall cylindrical bearing surface to supply the required degree of friction.

The floater bracket as seen from the sapphire consists of a plate on the right hand side which is attached to the recording machine, and which carries the right hand knife edge. Fixed to this plate is a "U" section arm of aluminium which passes clear over the top of the spectacle plate. Attached to this on the left is a side member which comes down from it and which supports the left hand knife edge.

Attached to the side of the spectacle plate are the steel V blocks which rest on these knife edges. Sufficient clearance is left between the spectacle plate and the arm of the floater bracket to enable the recorder to be removed by simply lifting it off the knife edges and withdrawing it in the direction of the sapphire. The terminals for the field and speech circuits may be connected to the top arm of the floater bracket and flexible leads pass from these terminals to the recorder itself.

The knife edges have small lateral projections left on them very close to the edge itself, which projections bear lightly against steel plates on the side of the spectacle plate and thus

prevent lateral movement. By making these projections close to the knife edge, the velocity of rubbing at these points is kept low, and the friction introduced is small.

It is to be understood that while the above described invention is directed more particularly to sound-recording apparatus, it is not limited such application since clearly the principles set forth may be applied o any apparatus having floating members of a character similar to that described. Further it must be understood that the invention is not limited to any of the details described, which are given purely by way of example; since we may modify and/or rearrange and/or omit various parts referred to, and/or include additional parts in order to carry the invention into effect and to achieve the desired objects without in any way departing from the scope thereof.

Dated this 1st day of December, 1930.

MARKS & CLERK.

COMPLETE SPECIFICATION

Improvements in and relating to the Mounting of Pivoted Apparatus, such as Electrical Sound Recording Devices

We, ALAN DOWER BLUMLEIN, of 57, Earl's Court Square, London, S.W.5, and HERBERT EDWARD HOLMAN, of 64a, The Chase, Clapham Common, London, S.W.4, both British subjects, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:-

This invention relates to the mounting of apparatus having motion above a fixed axis and is directed more particularly to the mounting of electrical devices employed for recording sound on wax discs.

In such devices the recording stylus in addition to being subjected to lateral vibratory motion whereby the sound record is made, is usually so mounted that it may have some vertical movement to accommodate for any irregularities in the wax surface and maintain a uniform depth of cut. The inertia of the apparatus in response to such movement naturally has considerable effect upon the accuracy and sensitivity of the recording, and one object of the present invention is to overcome previous inertial difficulties and thereby to improve the accuracy and sensitivity of the apparatus and to extend the working sound-frequency range to which it will response. It has previously been proposed to add a ballast weight to an electric pick-up in order to counterbalance it about a horizontal pivotal axis, whereby its load on the record may be modified, the moment of inertia of the whole mass being kept a low as possible. The present invention is directed to apparatus in which the inertia at the point of application of forces is kept as small as possible by design of the pivoted mass.

The invention consists in pivotally mounted apparatus, to which forces tending to move it about its pivot are applied at a point remote from the pivotal axis, wherein the pivots, e.g. knife edges, are so positioned that the effective inertia of the apparatus at the point at which the forces are applied is not more the 25% greater than its minimum value.

The invention further consists in pivotally mounted apparatus as set forth above wherein the pivot is positioned upon the line joining the centre of gravity of the apparatus to the point at which forces are applied and at a distance *d* from the centre of gravity on the side opposite to the said point of application of the forces; where *d* = EQUAT. HERE K being the radius of gyration of the pivoted member about its centre of gravity in a plane normal to its pivotal axis and *l* being the distanced between the centre of gravity of the pivoted member and the said point at which forces are applied.

The invention also consists in pivotally mounted apparatus as set forth above wherein the pivot is placed at the centre of gravity of the pivoted member, K being not greater than EQUAT. HERE; where K is the radius of gyration of the pivoted member about its centre of gravity in a plane normal to the pivotal axis; and *l* is the distance between the centre of gravity of the pivoted member and the point at which the forces are applied.

The invention also consists in a sound recorder, more especially of the moving coil type, pivotally mounted as set forth above.

The invention also consist in a sound recorder as set forth above wherein the point at which the forces tending to move the pivoted member are applied consists in a wax cutting sapphire or like took, resting upon the wax surface, the line joining the sapphire to the pivotal axis being included at an angle of between 30° and 50° to the wax surface, and preferably at approximately 40°.

The invention further consists in apparatus, e.g. a sound recorder, according to any preceding paragraph wherein damping means are provided to prevent undesirable oscillations of the pivoted member.

Further features of the invention will become apparent from the following description of one modification thereof, which will be given with particular reference to sound-recording devices disclosed in our Patent Specifications Nos. 350,998 and 350,954 but must be understood they have a wide field of application in connection with many other forms of sound-recording devices and other kinds of apparatus in general, and is not therefore limited to use with the particular form of apparatus described.

In order that the invention may be more readily understood reference will be made to the accompanying drawings wherein:-

Figure 1 represents a side view, and

Figure 2 an end view, remote from the stylus, of a sound recorder in accordance with the invention.

The apparatus disclosed in Specification Nos. 350,998 and 350,954 referred to, as shown in Figures 1 and 2, comprises a field system formed of a U-shaped electromagnet *a* (on the arms of which are mounted bulky energising windings *b*), between the poles of which is pivoted a moving coil *c* whereby the recording stylus *d* is operated. Current is induced in the moving coil by windings of another magnetic circuit mounted to intercept the field of the U-shaped electromagnet at right angles. The moving coil thus forms a secondary winding in the actuating magnetic circuit and, being mounted in a magnetic field of great strength, oscillates in a manner suitable for cutting a wax disc *e*. In general the moving coil is pivoted about a

vertical axis as shown, while to allow for unevenness of the disc surface movement of the whole device is desired about a horizontal axis; and it will be seen that the association with the field system *a* of another comparatively heavy magnetic circuit through the coil *c*, and the necessity of extensive and bulky windings *b* on the field system, render delicate mounting of the device a matter of great importance.

In carrying the present invention into effect in one convenient manner in connection with the apparatus descried, the whole recording device may be supported in a spectacle plate *f*, preferably of cast aluminium, which may be clamped round the field coil bobbins of the U-shaped electromagnet *a* forming the field system. These bobbins are completely enclosed by aluminium tubes *g* of accurate dimensions which thus form a firm foundation on which the spectacle plate *f* may be clamped. On the outer flat surfaces of the spectacle plate are screwed blocks *h*, preferably of steel, provided with V-shaped notches *i* adapted to rest on knife edges *k* provided on the bracket *r* which carries the device. The spectacle plate is preferably quite light, thus forming a firm holder for the recorder without the addition of any appreciable inertia.

For the best results the blocks *h* which determine the position of the floating axis must be secured in an optimum position, and it has been found that in order to obtain minimum needle point inertia, the optimum position of the floater axis is not the centre of gravity of the recorder, but a point more remote than this from the cutting sapphire. The optimum point lies on a line drawing through the sapphire point and the centre of gravity of the recorder and at a distance *d* from the centre of gravity where *d* is given by

EQUAT. HERE

where K is the radius of gyration of the apparatus in the plane of floating, about its centre of gravity and *l* is the distance between the stylus point and the centre of gravity. Such movement of the floater axis entails the introduction of a spring or other counterbalancing means in order to reduce or completely counterbalance the excess of weight of the recorder on the wax so as to regulate the depth of cut.

It has been found that in some cases the value of K can be made small compared with *l*, so that the reduction in sapphire point inertia due to removing the floater axis from the centre of gravity to the optimum point is negligible, and in this case it may be desirable not to move the axis from the centre of gravity. If K is not greater than half *l* the needle point inertia is not more the 25% greater than its minimum value which it reaches when the floater axis is moved back by the amount indicated above, and in these circumstances such movement is not necessary. It will be clear therefore that in accordance with the invention if K is not greater than half *l* the floater axis may pass through the centre of gravity of the device, while if K is more than half *l* the floater axis is positioned in accordance with the formula given above.

Another condition for satisfactory floating has been observed. In order that a recorder may produce a uniform depth of cut in an uneven wax blank, it is necessary that a small increase of depth of cut should produce as large an acceleration as possible of the recorder upwards, or vice versa, so as to restore the correct depth as quickly as possible. In practice a cutting sapphire is used with its cutting face approximately perpendicular to the wax surface, under which conditions the bulk of the reaction on the sapphire is due to the pus of the wax against

his flat surface. This push is practically tangential to the wax surface. There is a small component normal to the wax surface contributed by the pressure of the wax against the cutting edge itself, and also sue to the friction of the wax chips against the sapphire while they are removed. Broadly speaking, the resultant force of the wax on the sapphire seldom acts at a grater angle than 5° above tangential to the wax surface, unless a loping sapphire cutting surface

is used.

In order that irregularities in the surface of the wax blank may be accommodated, it is necessary that an increase of depth of cut shall produce an upward motion on the sapphire, and so restore the depth of cut to its right value. If the sapphire sinks too deep into the wax, the area of wax removed is increased and there is an increase in the wax force on the sapphire. This increase of force, which is almost tangential to the wax must be arranged to produce a vertical movement in the sapphire. If the recorder is floating abut a pivotal axis which is very close to the surface of the wax, the moment of this excess force about the floating axis will be very small, with a consequent small rise of the sapphire. If the floating axis is almost directly above the sapphire, the excess was load on the sapphire will produce a large moment about the pivotal axis, but it will require a large angular movement of the recorder to relieve appreciably the depth of cut.

It will be seen therefore, that for a given inertia, or resistance, to movement about the rotational axis, at the sapphire, the largest movement will be obtained vertically for a given horizontal force, when the line drawn from the sapphire to the floating axis subtends an angle of 45° to the wax. When the resultant force of the wax on the sapphire lies at an angle *a* to the wax surface the best angle for the sapphire-floating axis line is EQUAT. HERE to the wax surface.

It will be seen therefore that the best angle for the sapphire-floating axis line or best floating angle, is somewhere between 30° and 50°, the preferred range being 35° to 40°. There is a small advantage in not making this angel too large, as if it is excessive, the horizontal movement of the recorder sapphire for each vertical movement is accentuated, with a consequent variation of recording speed on an uneven was blank. This condition of floating angle gives an optimum effective lifting force for a given wax load force.

While, as described above, it is desirable that effective restoring forces shall be brought quickly into play upon displacement of the stylus, it is essential that the return movement of the device shall be substantially dead-beat to avoid any vertical oscillatory action of the stylus on the wax. This restoring force is in the nature of a stiffness since the restoring force is proportional to the increase or decrease of depth of cut. The ratio of the restoring force to the change of depth of cut defines the value of the effective stiffness.

If the recorder is freely suspended, there will be a tendency for a small irregularity in the wax to start the recorder bounding, the period of bound being defined by the sapphire point inertia and the effective stiffness of the wax restoring force. It is necessary therefore to introduce damping into the movement of the recorder on its pivotal axis. Such damping should preferably be "true damping" in that the damping force should be proportional to the velocity of movement. Oil damping is very well suited to the purpose, though other forms may obviously be used. The damping necessary may be determined as follows:-

A force of "*p*" dynes is applied to the sapphire at right angles to the floater axis — sapphire line, and the change of depth observed. Let this observed change of depth be such as to involve a movement of the sapphire of "*a*" cms, which movement should not be sufficient to spoil the proportionality of the effect. The "stiffness" will then be give by EQUAT. HERE.

Let the distance from the sapphire to the floating axis be equal to *b* cms. Then the torsional stiffness due to the wax will be EQUAT. HERE dynes cm/radian. To this must be added any additional stiffness due to springs for adjusting depth of cut, suspension springs, etc.

Let the moment of inertia of the recorder about the floating axis be I gram cms^2. Then the bound frequency, *f*, will be given by:-

F = EQUAT. HERE cycles per second

This bounce frequency of a recorder may be observed by removing the damping without altering the mass or stiffness and cutting a wax blank. The mechanical damping *r* necessary to produce critical damping in such a system will be given by:-

r=2 EQUAT. HERE dyne cm/radian/sec.

For satisfactory operation the damping applied should approximate to, or be slightly greater than, that given by the above expression. The limits within which *r* should lie are about 0.5 to 2.0 times the critical value, the preferred range being 1.0 to 1.5 times the critical damping. This damping, as indicated, may be effected by any suitable means (e.g. mechanical friction, fluid viscosity, electrical) and may, for example, take the form of a dash-pot *m* arranged, or, if desired, adjustable, so that while allowing the recorder to assume normal position as soon as possible after displacement, it nevertheless prevents overshooting. The arrangement may comprise an arm *n* projecting, preferably away from the stylus, horizontally from the spectacle plate, to the end of which arm is secured a flat, preferably circular, disc *o*. This disc *o* dips into a cylindrical cup *m* containing any suitable damping fluid such as water, oil, a mixture of oil or of oil with benzine, which cup *m* is fixed rigidly to the supporting bracket by an arm *p*. It must be understood that damping in the form of blades or vanes adapted to move in a dash-pot of oil has previously been suggested for sound-recording apparatus and no claim is made herein to such a feature per se.

Alternatively (more especially if the floating mass is not large or if, only small irregularities of the wax surface are anticipated) the dash-pot may be dispensed with and friction damping employed. Such means may comprise a small brake bearing on a cylindrical surface on the spectacle plate coaxial with the floater axis; or the knife edges may be rendered blunt to give a small cylindrical bearing surface to supply the required degree of friction.

In any case, where or not other damping means are employed, it is preferably that the knife edges be rounded rather than sharp, although they work in sharp V notches. The radius of curvature is made so mall that although very little frictional damping is provided, the advantage of a small diameter journal bearing are obtained together with increase supporting strength of the edge.

The floater bracket *r* consists of a plate *s* on one side which is attached to the recording machine, and which carries one knife edge *t*. Extending from this plate is a "U" section arm *u*

of aluminium which passes clear over the top of the spectacle plate, and carries a side member *v* which comes down from it and which supports the other knife edge *k*.

Attached to the side of the spectacle plate are the steel V blocks *h* which rest on these knife edges *t, k*. Sufficient clearance is left between the spectacle plate and the arm of the floater bracket to enable the recorder to be removed by simply lifting it off the knife edges and withdrawing it in the direction of the sapphire. The terminals for the field and speech circuits may be connected to the top arm of the floater bracket and flexible leads pass from thee terminals to the recorder itself.

The knife edges *t, k* have small lateral projects left on them very close to the edge itself, which projections bear lightly against steel plates on the side of the spectacle plate and thus prevent lateral movement. By making these projections close to the knife edge, the velocity of rubbing at these points is kept low, and the friction introduced is small.

It is to be understood that while the above described invention is directed more particularly to sound-recording apparatus, it is not limited to such application since clearly the principles set forth may be applied to any apparatus having floating members of a character similar to that described. Further it must be understood that the invention is not limited to any of the details described, which are given purely by way of example; since we may modify and/or rearrange the various pats in order to carry the invention into effect under various conditions and requirements to be fulfilled, and to achieve the desired objects without in any way departing from the scope thereof as defined by the appended claims.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:-

1. Pivotally mounted apparatus, to which forces tending to move it about its pivot are applied at a point remote from the pivotal axis wherein the pivots, e.g. knife edges, are so positioned that the effective inertia of the apparatus at the point at which the forces are applied is not more than 25% greater than its minimum value.
2. Pivotally mounted apparatus as claimed in Claim 1 wherein the pivot is positioned upon the line joining the centre of gravity of the apparatus to the point at which forces are applied and at a distance *d* from the centre of gravity on the side opposite to the said point of application of the forces; where d = EQUAT. HERE, K being the radius of gyration of the pivoted member about its centre of gravity in a plane normal to its pivotal axis and *l* being the distance between the centre of gravity of the pivoted member and the said point at which forces are applied.
3. Pivotally mounted apparatus as claimed in Claim 1 wherein the pivot is placed at the centre of gravity of the pivoted member, K being not greater than EQUAT. HERE; where K is the radius of gyration of the pivoted member about its centre of gravity in a plane normal to the pivotal axis; and *l* is the distance between the centre of gravity of the pivoted member and the pint at which the forces are applied.
4. A sound recorder, more especially of the moving coil type, pivotally mounted as claimed in Claim 1, 2 or 3.
5. A sound recorder comprising a field magnet (preferably a U-shaped electromagnet) between the poles of which is pivoted a coil adapted to oscillate in accordance with the sounds being recorded and thereby to operate the recording tool, the whole being pivotally mounted according to Claim 1, 2, or 3.

6. A sound recorder as claimed in Claim 5 wherein the pivoted member is securely clamped within a plate (e.g. a spectacle plate adapted to fit tightly to the field system) whereby supporting pivots are provided for floating it.
7. A sound recorder as claimed in Claim 4, 5 or 6 wherein the point at which the forces tending to move the pivoted member are applied consists in a wax cutting sapphire or like tool, resting upon the wax surface, the line joint the sapphire to the pivotal axis being inclined at an angle of between 30° and 50° to the wax surface, and preferably at approximately 40°.
8. A sound recorder according to any preceding claim wherein the pivoted member is provided with V-shaped notches or notched member adapted to rest on knife edges provided on a suitable bracket (e.g. an inverted U-shaped arm rigidly secured to the recording machine).
9. A sound recorder as claimed in Claim 8 wherein the knife edges are blunt or "rounded" to a small radius to act as a small diameter journal bearing.
10. A sound recorder as claimed in Claim 8 or 9 wherein projects (preferably very near the pivotal axis) are provided on the knife edge members adapted to bear lightly against the pivoted member, or attachments thereto, in order to eliminate lateral play thereon.
11. Apparatus, e.g. a sound recorder, according to any preceding claim wherein damping means are provided to prevent undesirable oscillations of the pivoted member.
12. Apparatus according to Claim 11 wherein the damping force is proportional to the velocity of moment of the pivoted member.
13. Apparatus as claimed in Claim 11 or 12 wherein the damping applied is between 0.5 and 2.0 times the critical damping, and preferably between 1.0 and 1.5 times the critical damping, as defined herein.
14. A sound recorder according to claim 11, 12 or 13 wherein damping is effected by a piston attached to the pivoted member adapted to move in oil, or any other suitable fluid, enclosed in a dash-pot rigid with the supporting bracket.
15. Apparatus, more especially a sound recorder, substantially as described herein with reference to the accompanying drawings.
16. Sound recorders whenever prepared by apparatus substantially as described herein with reference to the accompanying drawings.

Dated this 1st day of October, 1931.

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