

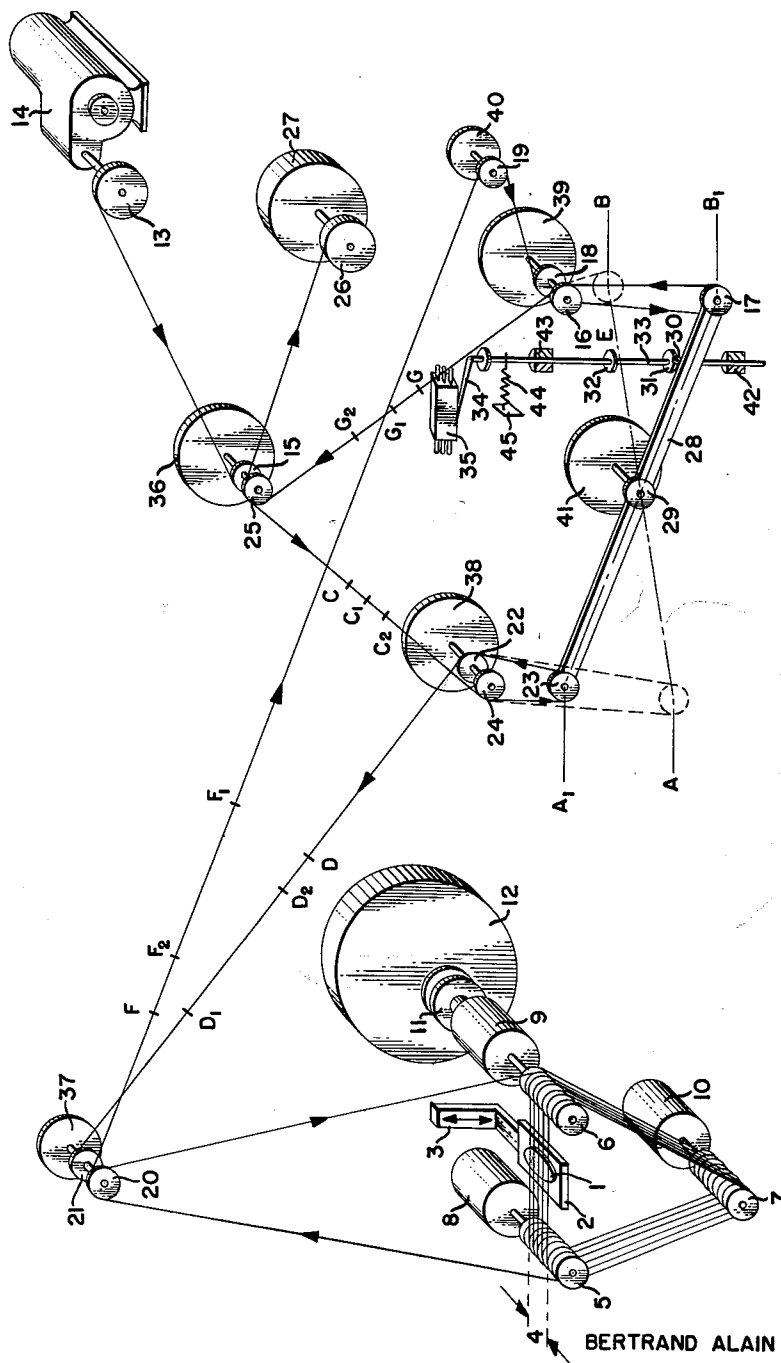
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MACHINE FOR SAWING SAMPLES OF BRITTLE MATERIALS

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1

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MACHINE FOR SAWING SAMPLES OF
BRITTLE MATERIALS

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The present invention is concerned with the sawing of samples of brittle materials, especially crystalline materials such as quartz, ceramics and simple or complex crystals of any kind, including the crystals of semiconductor materials previously doped or not and previously or not assembled to metal contact layers.

The invention relates to sawing machines for the above-defined materials which act by rubbing said material samples with an array of metal wires against which they are placed while driven in an alternating lateral motion within an abrasive medium.

The object of the invention is to provide such a machine whereby the fineness and accuracy of the cutting of the samples are substantially increased with a reduced danger of deterioration of the materials.

In prior machines of this kind, it was conventional to produce the alternating motion of the wire array by means of mechanical or electromechanical gear systems. At the occurrence of each reversal of the direction of the alternating motion, the wires were submitted to repeated jolts producing strains and stresses within their metal structure which lead to damages up to rupture though such wires were made of hard material such as tungsten for instance. The rubbing array was rapidly worn out and so were the wireguides and rollers over which said wires were passing. As the rubbing of the wires on the materials to saw uses the wires of the array, it has been provided to constitute such an array from a single wire which is several times wound over wire-guides having multiple grooves, the said wire being fed from a single spool magazine and being drawn to a final receiving spool, under the control of a beam-arrangement. Such an arrangement provides a continuous renewal of the wire in the array. This does not avoid the above mentioned drawback and further introduces the additional condition of a constant pull on the wire during the movements thereof. The wire was pulled by jolts from the feeding spool and on the receiving spool, and an arrangement of tackle-block and counter-weight was used, without much efficiency though with an increase of the cumbersomeness of the machine.

According to a feature of the invention, in a machine of the above kind wherein a single wire array is submitted to an alternating motion while said wire is continuously translating from a feeder to a receiver spool, the receiver spool is driven permanently by a constant torque motor supplied with electrical current for freely running at a higher speed than the actual speed it is reduced to by the traction of the wire, and the feeder spool is mounted on the shaft of a small slow rotation motor acting as a brake and regulator of the feed of said wire to said array.

According to a further feature of the invention, a constant torque motor for this machine is a printed-circuit armature motor of the kind described in co-pending U.S. application Serial No. 1128 of Jacques Henry-Baudot filed on January 7, 1960. It is an axial airgap motor the armature of which comprises two sets of half-turn conductors on the opposite faces of an annular carrier; such a rotor is totally deprived of iron slots and consequently does not present any flux modulation while working at a constant torque on its rotation shaft.

According to a further feature of the invention, the movement of the wire array is controlled by a printed-

2

circuit armature motor, wherein the armature is damped by means of a conductive ring in the rotor structure, as disclosed in the said co-pending application, said printed-circuit armature driving one of the multiple-guides of the array of wires, the same kind of motor being used for the drive of the receiver spool of the wire in order to avoid any jerks by accurately and swiftly following the reversals of motion (direction of rotation) according to reversals of the supply current to its armature.

These and further features will be described in detail with reference to the single figure of the accompanying drawing which shows an illustrative embodiment of the machine.

The material sample to be sawn by placing it in contact with a metal wire array is shown at 1 carried by a supporting member 2 mounted upon a slide 3 for enabling the application with pressure of said sample under the wire array 4 defined by the multiple-grooved wire guides 5, 6 and 7 on bearings 8, 9 and 10 respectively. The axle of the wire guide 6 is connected by a flexible coupling 11 to the shaft of a motor 12 of the printed-circuit damped armature kind. An inertia fly-wheel may be added to the axle of 6, when required. During the working periods of the machine, the wire array and the sample are sprayed with an abrasive mixture containing Carborundum dissolved or dispersed into water solution containing about 10% of soluble petroleum oil. The wire-guides and the rollers in the machine are preferably made of a soft material such as red copper or Duralumin (an aluminum alloy), which is also cheap per se.

The wire is obtained from a feeder spool 13 carried on the shaft of a motor 14 of slow and adjustable speed. The speed adjustment may be obtained from a potentiometer on the supply of the motor, when required. This speed is for instance lower than twelve r.p.m. The wire is received on a receiver spool 26 after a complete path through the machine and said receiver spool is driven permanently by a motor 27 operating at a constant torque, as being fed with an electrical supply which would drive it at a faster speed than the speed of advance of the wire through the machine. As the restraining action of the stretched wire slows down the motor 27, though it works with a constant torque, the mechanical strain or stretch on the wire is constant throughout the advance of the wire in the machine, from the feeder spool braked by the slower rotation of the motor 14 up to the receiver spool driven by the motor 27.

The path followed by the wire through the machine includes two active places, the place of the array and the place of the toggle, the latter indicated generally by the numeral 28A, plus of course several passive points of routing between the spools and said two places. At such passive routing places, the wire passes over rollers unclamped on their axles, said axles being secured to pieces which will be mounted on the base walls, not shown. At the output from feed spool 13, the wire passes over the roller 15, the axle of which is secured to the mounting plate or piece 36; said roller 15 routes the wire to the roller 24 wherein it enters the toggle, left portion (on the drawing). At the output of the said toggle, roller 22, the wire passes over the roller 21 mounted on the plate 37 and enters the wire-guide 6, input of the array forming and controlling arrangement in the machine. Leaving the array, the wire passes over the roller 20 which routes it to the roller 19 mounted upon the plate 40 and further to the roller 18, input of the other part of the toggle arrangement. The wire, when leaving said toggle branch, is routed by the roller 25 to the receiver spool 26.

The toggle arrangement comprises on the one hand a bar 28 pivoted at 29 on a mounting plate 41 by means of a roller-bearing for instance or similar device, and equipped at each end with sets of rollers 17 and 23.

Only one roller is shown at each place, but in actual practice, several may be paralleled, when required. The toggle also comprises, on fixed mounting plates, 38 and 39, sets of rollers 22, 24 in association with roller(s) 23 and respective sets of rollers 16, 18 in association with roller(s) 17. An advantage of providing several turns of the wire in the input and output arrangement of the toggle lies in the fact that the values of the displacements of the wire are increased, leading to a faster cutting of the sample, and also to reduce the frequency of the reversals of motion of the driving wire-guide 6 from less frequent reversals of the direction of rotation of the motor 12.

The arm 28 of the toggle arrangement is equipped with a pawl or tab 30 reciprocating between two abutments 31 and 32 carried by a rod 33 guided for sliding within bearings 42 and 43 on the base plate of the machine, not shown. The rod 33 is laterally attracted by means of a spring 44 secured at 45 on the said base of the machine; the rod consequently is frictionally held in its bearings so that it remains in any position to which it has been brought. The rod 33 terminates in a pusher 34 which at the upper position of the rod, actuates a reversing switch 35 for the control of the reversal of the electrical supply of the motor 12, consequently a control of the reversal of the direction of rotation of said motor 12 and the wire-guide 6, with respect to the direction of rotation of said members when the rod is in its lower position (upper and lower on the drawing). The details of the reversing contacts 35 are not given since they are conventional per se. The reversal of contacts is controlled from the movement of the toggle, as apparent, which at each oscillation thereof, reverses the direction of rotation of the motor 12 and consequently the direction of transverse drive of the array of metal wire over the sample to saw. The abutments 31, 32 on rod 33 and the co-operating tab 30 on bar 28 constitute a lost-motion connection between bar 23 and the switch control rod 33, to reverse the switch at the end positions of travel of bar 28.

The operation may be explained as follows: considering two points C and D on the wire, in the "new" portion thereof, prior to the array, and two points F and G on said wire in the "old" portion thereof, after said array 4, the relative position of the four points C, D, F, G is defined for a position A-B of the toggle. Now the toggle comes to the position A₁-B₁, the points come to places C₁, D₁, F₁ and G₁ respectively. Distance DD₁ is equal to twice distance AA₁, plus CC₁ and distance FF₁ is equal to twice distance BB₁, plus GG₁. As AA₁ is equal to BB₁ and as DD₁ is equal to FF₁, the distance GG₁ is equal to the distance CC₁ and the "old" wire must be wound on 26 at the same speed the "new" wire is unwound from 13. This is obtained by adjustment of the speeds of the motors 14 and 27.

When the toggle has come to the A₁-B₁ position, a reversal of direction of rotation of the motor 12 has occurred. The stretch of the wire produces the return of the toggle to the position A-B, and points C₁, D₁, F₁ and G₁ on the wire respectively come to C₂, D₂, F₂ and G₂, from the displacement of the rubbing wire array. Again D₁D₂ equals C₁C₂ minus twice A₁A and F₁F₂ equals G₁G₂ minus twice B₁B, which does not change the necessary relative speeds of the motors 14 and 27. Finally, during a complete cycle of the rubbing array, forth and back, the distance of advancement of points D and F of the wire equals the advance of the points C and G. The wire is evenly maintained stretched at a constant value and this is only dependent on the supply from the feeder spool 13, once the adjustments are made. Consequently the array 4 is driven in a reciprocating motion at a smooth drive and the wire is continuously "freshened" up without

any stress or restraint, in an equally smooth movement of advance from the feeder to the receiver spools. The above implies a single roller at 23, 24, 16 and 17. It would be the same if several turns of the wire were made in the toggle arrangement over as many rollers.

As illustrative the performance of the invention disclosed herein, the following results were obtained. The accuracy in the sawing of semiconductor materials was within 0.01 millimeter in contrast to an accuracy of 0.1 millimeter obtained with a diamond saw. Using a wire with a diameter of 0.1 millimeter with a machine described herein a saw line width of 0.12 millimeter was obtained as contrasted with a saw line width of 0.7 millimeter obtained by other methods. It has been possible with this machine to cut 1300 small bars from a cylinder 20 millimeters in diameter and 3 millimeters in length.

It is to be noted that it is quite easy, in such a machine as described, to provide an array comprising 40 wire lines or more, of the above-said diameter, without any fear of ruptures or breaks of the wire in such an array.

What is claimed is:

1. In a machine for sawing samples of a material comprising a reciprocating wire array for sawing material, said array comprising a plurality of wire guides and a single wire passing a plurality of times over said guides, a feeder spool for said wire, a control motor energized to rotate at a speed slower than that of said feeder spool and connected to said feeder spool, said control motor acting as a brake and feed regulator, a receiver spool for said wire, a constant torque drive motor for rotating said receiver spool, means for electrically controlling said constant torque drive motor for a tendency to rotate at a speed higher than the stretch of the wire will permit, a constant torque reversible motor driving at least one of said wire guides thus defining a rotary reciprocating guide, and means including a toggle member carrying said wire for causing said reversible motor to reverse.

2. A machine according to claim 1, wherein both the motor which drives the wire guide in the array and the motor driving the receiver spool are printed-circuit armature, axial airgap machines.

3. A machine as defined by claim 1 in which said rotary reciprocating guide is connected directly to the shaft of said constant torque reversible motor.

4. In a machine for sawing samples of a material into a plurality of parts and including a multi-turn wire array driven by a reversible motor, and a reversing switch for said motor controlled by a reciprocating member operating in different directions in accordance with the direction of operation of said wire array, the improvement comprising a switch control member mounted for movement between two positions, means for frictionally holding said switch control member in either position, and a lost-motion connection between said reciprocating member and said switch control member for moving said control member from one position to the other, and vice versa, at the end positions of said reciprocating member.

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