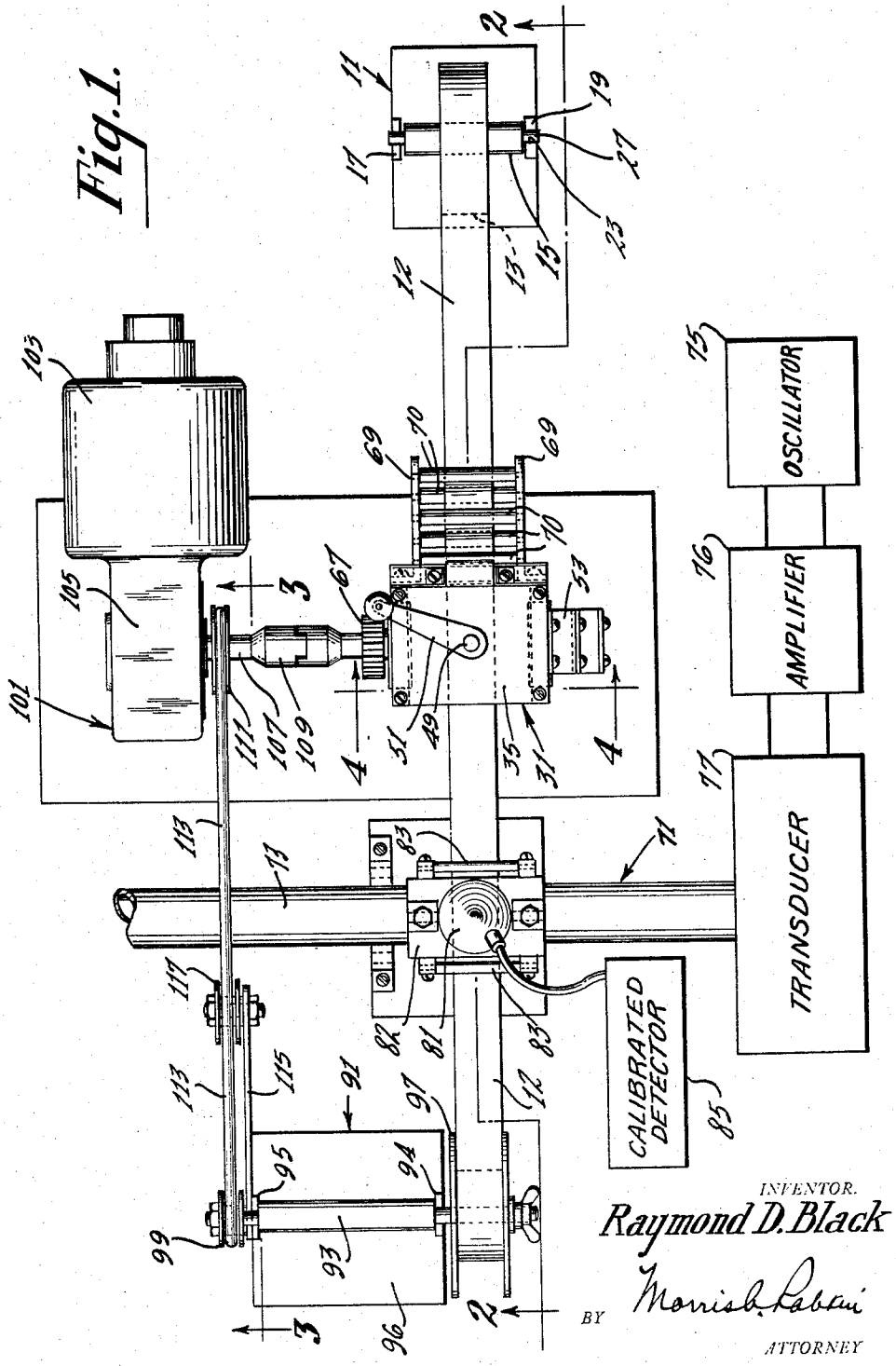
Nov. 24, 1959 R. D. BLACK 2,913,838

APPARATUS FOR PROCESSING ACOUSTIC DAMPING MATERIAL

Filed June 1, 1954 2 Sheets-Sheet 1

Fig. 1.



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Filed June 1, 1954 2 Sheets-Sheet 2

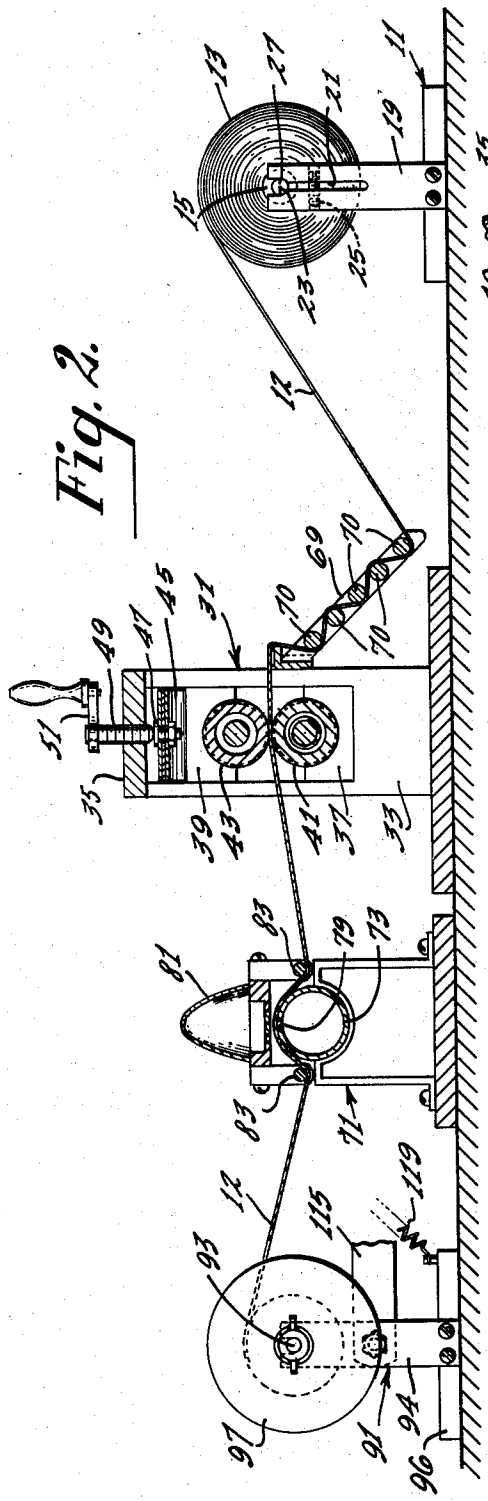


Fig. 2.

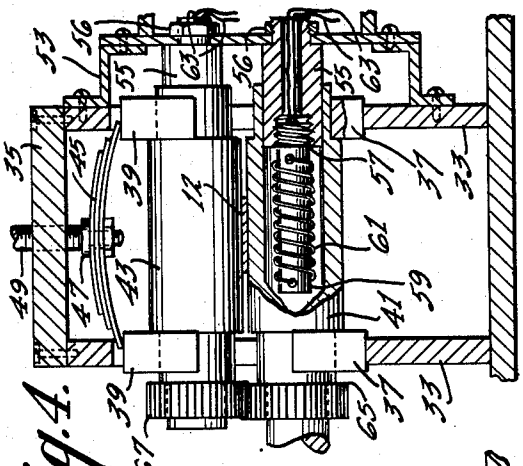


Fig. 4.

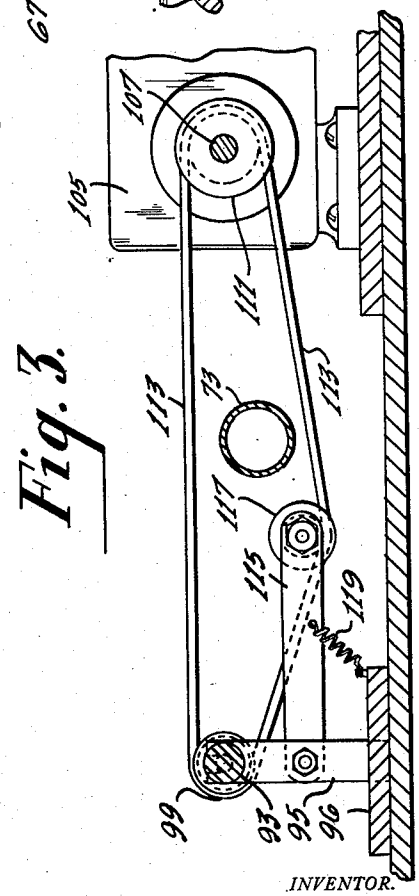


Fig. 3.

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United States Patent Office 2,913,838 Patented Nov. 24, 1959

2,913,838

APPARATUS FOR PROCESSING ACOUSTIC DAMPING MATERIAL

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Application June 1, 1954, Serial No. 433,636

5 Claims. (Cl. 38—44)

This invention relates to an apparatus for processing acoustic damping materials, and, and particularly, to a mechanism for obtaining damping material with a uniform prescribed acoustic impedance.

One of the problems involved in controlling the response of acoustic transducers is that of obtaining a damping material with a given acoustic impedance. The high frequency response, particularly of the smaller transducers such as microphones and earphones, is often greatly affected by the damping material used in the front cavity. For example, in many cases transducers have been designed to meet certain requirements and it has been found that the high frequency limits had to be controlled with a damping material having specific acoustic properties. In the experimental stages of such a transducer various damping materials are used until the one giving the desired amount of control is found.

The problem becomes more difficult due to the fact the although one piece of material may give the desired results, a second sample from the same piece of material, taken some distance from the first sample, may give undesirable results while a third sample may react differently from the first two. This is due to the fact that normal weaving processes do not produce a material having uniform acoustic properties.

An object of this invention, therefore, is to provide a mechanism for processing a woven material so that it has uniform acoustic damping properties.

Another object of this invention is to provide a mechanism for simultaneously processing a material to achieve certain acoustic properties and measuring the acoustic properties of the material.

A further object of this invention is to provide a mechanism for processing a woven damping material to maintain the acoustic impedance of the material within certain predetermined parameters.

In accordance with the present invention, a mechanism for accomplishing these objects comprises a calender, means for keeping a substantially constant tension on a strip of material entering the calender, a device for measuring the acoustic impedance of the strip as it passes through the device, and means for keeping a substantially constant tension on the strip as it passes said measuring device. The acoustic impedance of a woven material may be controlled by the application of heat, by the speed of calendering or by the pressure applied in the calendering process. One or more of these variables may be controlled to keep the acoustic impedance of a continuously moving strip of material within predetermined limits or parameters.

The novel features of the present invention, as well as additional objects and advantages thereof, will be understood more fully from the following description when read in connection with the accompanying drawings, in which:

Figure 1 is a plan view of one form of apparatus according to the present invention;

Figure 2 is a view in sectional elevation of the apparatus taken along the line 2—2 of Figure 1 and looking in the direction of the appended arrows;

Figure 3 is a view in sectional elevation of a portion of the apparatus taken along the line 3—3 of Figure 1 and looking in the direction of the appended arrows; and

Figure 4 is a view in sectional elevation of the calender taken along the line 4—4 of Figure 1 and looking in the direction of the appended arrows.

In the illustrative embodiment of the invention exemplified in the drawing, in which similar characters designate similar parts throughout, a complete apparatus includes a supply spool assembly **11**, a calender **31**, an acoustic impedance measuring device **71**, a take-up spool mechanism **91** and a driving mechanism **101**. This apparatus has been designed to calender a strip of thermoplastic material **12**, such as "nylon" or "Orlon" for example.

A spool **13** of the material to be processed is mounted on a shaft **15** which is carried by bearing brackets **17** and **19**. One of these brackets **19** has a longitudinal slot **21** extending downwardly from the bearing **23**. A screw **25** which is set in the bracket transversely of the slot **21**, is provided so that the arms of the bracket **19** formed by the slot may be drawn together. Hence the pressure between the bearing portion **23** of the bracket **19** and the journal **27** of the shaft **15** may be varied to control the rotation of the shaft by means of friction.

The calender **31** is carried in a frame comprising essentially two side members **33** and a top member **35**. A pair of bearings **37** and **39** are mounted in each of the side members **33**. These bearings are mounted for sliding movement in a vertical direction and support, respectively, the calender rollers **41** and **43**. Looking in the direction of the roller axes, the bearings **37** and **39** have a substantially U-shaped contour and the bearing surfaces thereof are semi-circular in contour. The lower bearings **37** will exert an upward pressure on the roller **41** while the upper bearings **39** exert a downward pressure on the roller **43**. A leaf spring **45** is supported across the top of the calender and one end thereof engages each of the upper bearings **39**. The spring is held together at its center by a securing member **47** which also provides a bearing surface. A threaded stud **49** is secured in a tapped hole provided in the upper member **35** of the calender frame and is aligned so that its lower end will bear on the bearing surface provided on the securing member **47**. A crank **51** is attached to the upper end of the screw **49**.

The rollers **41** and **43** are hollow and are open at one end so that heating elements extend within the rollers. In order to mount such heating elements, a bracket **53** is mounted on one of the side members **33**. A pair of hollow sleeve members **55** are rigidly attached at one end to the bracket **53** by means of nuts **56**, for example, and have tapped holes **57** provided in their opposite ends. These tapped ends of the sleeves **55** extend into the cavities in the rollers **41** and **43**. A ceramic coil holder **59**, for instance, is screwed into each of the tapped holes **57** and carries a heating coil **61** which will provide an even heat over the surfaces of the rollers. The coil **61** may be connected to a source of electrical energy, which is not shown, by means of lead wires **63**.

A pair of meshing gears **65** and **67** are attached to extensions of the rollers **41** and **43** to provide a positive drive for the rollers.

Mounted at the front of the calender is a ladder type bracket **69** carrying parallel bars **70** which are mounted transversely of the path of travel of the strip **12**. These bars **70** may be stationary or they may be in the form of rollers whose function is to smooth out the strip **12** as it passes between them, to provide a predetermined

amount of frictional drag and to provide an even tension across the strip.

The acoustic impedance measuring device **71** includes a hollow tube **73**, and a means for providing a known acoustic signal in the tube which means include an oscillator **75**, an amplifier **76** and a transducer **77**. A small aperture **79** is provided in the tube and is aligned so that the strip of material **12** will pass over this aperture. A microphone **81** is mounted on a support member **82** over the tube **73** so that its diaphragm is adjacent the aperture **79**. The support member **82** also carries a pair of parallel guide bars **83** positioned on either side of the tube **73**. These bars **83** hold the strip **12** against the tube **73** as it passes over the aperture **79** therein. The microphone **81** may be connected to an instrument such as a calibrated detector **85** which will give instantaneous readings of the signal picked up by the microphone as the material passes over the tube **73**. The acoustic impedance measuring device described herein by way of example is the subject matter of a copending application, Serial No. 412,360, entitled "An Acoustic Impedance Measuring Apparatus," filed on behalf of S. A. Caldwell and assigned to the assignee of the present application.

The take-up spool mechanism comprises a shaft **93** carried on bearing brackets **94** and **95** and carrying a take-up spool **97** fixed at one end thereof and a small belt pulley **99** fixed at the other end thereof.

A driving mechanism **101** comprises a motor **103** and a speed reduction mechanism **105**. The speed reduction mechanism is connected to the lower roller **41** of the calender **31** by means of a shaft **107** and a coupling **109**. A belt pulley **111** is mounted on a shaft **107**. This pulley **111** is aligned with the pulley **99** of the take-up mechanism and is somewhat larger in diameter than the pulley **99** so that the rotational speed of the shaft **93** will be somewhat greater than the rotational speed of the shaft **107**. This arrangement is required so that the take-up mechanism **91** will tend to draw the strip out of the calender rollers at a rate faster than the rate provided by the calender and hence provide a constant tension on the strip between these points. In order to provide this tension, a certain amount of slip will occur between the pulley **99** and a belt **113** which couples the pulleys **99** and **111**. In order to provide the required tension in the belt **113**, an arm **115** is pivotally secured at one end to the bearing bracket **95** of the take-up mechanism. An idler pulley **117** is mounted at the other end of the arm **115** and is positioned at a point which is intermediate the pulleys **99** and **111**. The arm **115** is biased to keep a constant tension on the belt by means of a spring **119** which is secured to the arm **115** at a point intermediate its ends and to the base member **96**.

Operation

A spool of material may be securely fixed to the shaft **15** by any known means. The strip from the spool is then fed through the parallel bars **70**, between the calender rollers **41** and **43**, through the measuring device **81**, and is attached to the takeup spool **97** which is fixed to the shaft **93**. The main drive for the strip is provided by the drive motor **103** through the calender rollers. The amount of drag on the strip may be varied by threading the strip through a greater or lesser number of bars or rollers **70** and also by adjusting the drag means provided on the bracket **19**.

The heat applied by the rollers **41** and **43** and the speed at which these rollers are driven is variable to extend the range of acoustic impedances that might be obtained from the apparatus. However, it has been found that with a fixed roller speed and with a fixed heat applied uniformly across the surfaces of the rollers, a wide range of impedances can be produced by varying the pressure of the rollers only. The present apparatus, therefore, is designed so that the pressure applied to the rollers may be varied during the operation of the apparatus.

The impedance measuring device must be calibrated prior to the processing of a strip of material. The method for doing this is described in detail in the above mentioned copending application and it is believed that a detailed description is not necessary here. Very briefly, however, this is accomplished by placing a material having a known acoustic impedance in the device, passing the known acoustic signal through it and observing the upper and lower limits of acceptable response as indicated on the calibrated detector. Having established these limits, the acoustic impedance of the production strip being processed may be kept within the limits by varying the pressure on the calender rollers. Since variations in the acoustic impedance usually occur gradually over wide areas of material, uniformity may be controlled by making a correction on the calendar when the detector indicates that the impedance is changing in one direction or the other.

In order to obtain accurate and consistent measurements, it is desired that a certain and substantially constant tension be provided on the strip **12** as it emerges from the calender **31** and passes over the acoustic measuring device **71**. Such tension is provided by the arrangement of the pulleys **99** and **111** and the means for keeping a tension on the belt **113** which couples these pulleys. The pulley **99** of the take-up mechanism is somewhat smaller than the pulley **111** of the drive mechanism. This means that the shaft **93** of the take-up mechanism will rotate at a faster rate than the shaft **107** of the drive mechanism. However, the linear rate of travel of the strip **12** is controlled by the calender rollers which are directly coupled to the shaft **107** so that the take-up mechanism, in attempting to drive the strip **12** at a faster rate, will create a tension on the strip.

To maintain this tension on the strip substantially constant, the belt **113** is permitted to slip on the pulley **99**. The torque applied to the pulley **99** by the belt **113** is controlled by the tension applied to the belt **113**, and this tension is, in turn, regulated by the idler pulley **117** and its biasing spring **119**.

With this mechanism, one of the problems in transducer design, that of obtaining damping material with certain acoustic properties, has been greatly reduced. When the acoustic parameters for the damping material necessary to obtain the desired response of a transducer have been calculated or measured, the limits may be transferred to the detector of the acoustic impedance measuring device. Material can be calendered and the desired acoustic impedance limits can be maintained at the same time. The result is a damping material with a uniform, prescribed acoustic impedance.

What is claimed is:

1. Apparatus for processing a continuously moving strip of a material to a uniform acoustic impedance comprising a calender having a pair of rollers, means for driving said rollers to drive said strip between said rollers at a fixed rate, means providing a continuous control for varying the pressure applied between said rollers, a take-up mechanism for said strip, means coupled to said roller driving means for frictionally driving said take-up mechanism, said take-up mechanism tending to draw said strip from said rollers at a rate faster than the rate provided by said rollers whereby a constant tension is provided on said strip, a mechanism for passing a known acoustic signal through said calendered and tensioned strip, and means for detecting said signal and indicating the impedance of said strip to the passage of said signal, said detected signal indicating the desired pressure variation to be applied to said rollers to provide a material having a uniform acoustic impedance.

2. Apparatus for processing a continuous strip of damping material to a uniform acoustic impedance while it is in motion, said apparatus comprising a calender having a pair of rollers for compressing said strip, means associated with said calender, for providing an even tension

across the width of said strip as it enters said rollers, a mechanism for producing a known acoustic signal and directing said signal through said compressed strip, means for detecting said signal and indicating the resistance of said material to the passage of said signal, said resistance being determined by the amount of compression and the amount of tension on said strip, means for driving said strip between said calender rollers and over said signal directing mechanism, means associated with said driving means for maintaining a substantially constant tension on said strip as it passes over said signal directing mechanism and means associated with said calender to provide a continuous control for adjusting the pressure between said rollers, said detecting and indicating means determining the desired pressure adjustment for providing a uniform impedance along said strip.

3. Apparatus for processing a continuously moving strip of a damping material while it is in motion to a uniform acoustic impedance, said apparatus comprising, in combination, a calender having a pair of rollers for pressing said strip, means for driving said rollers at a constant rate, means associated with said calender for readily varying the pressure applied between said rollers, means for holding a supply reel of said material, means for maintaining a constant and even tension across said strip as it enters said rollers, said tension maintaining means comprising a drag mechanism on said supply reel and a rack mounted adjacent said rollers carrying a plurality of parallel bars mounted transversely of said strip and ahead of said rollers, means for producing a uniform heat across the surfaces of said rollers, a take-up mechanism for said strip, means coupled to said roller driving means tending to drive said strip take-up mechanism at a rate faster than the driving rate of said rollers, said last-named means maintaining said strip under a substantially constant tension as it leaves said rollers, a mechanism positioned between said calender and said take-up mechanism for passing a known acoustic signal through said pressed and tensioned strip, and means for indicating the relative impedance of said calendered strip to the passage of said acoustic signal, said indicated impedance determining the variation in pressure to be applied to said strip.

4. Apparatus for processing a strip of woven material to a uniform acoustic impedance comprising a calender having a pair of rollers for compressing said strip of material, means for readily varying the pressure between said rollers, means for driving said rollers whereby said strip is drawn through said rollers at a uniform rate, smoothing means comprising a rack positioned ahead of said rollers carrying a plurality of parallel members mounted transversely of the direction of movement of said strip to provide a tortuous path for said strip, means driven by said roller driving means for drawing said compressed strip from said calender, said strip drawing means tending to draw said strip at a rate faster than the rate provided by said roller driving means whereby a constant tension is maintained on said strip as it is drawn from said rollers, means for passing a known acoustic signal through said compressed and tensioned strip, means for translating said acoustic signal into an electrical signal, and means for measuring said electrical signal to provide a continuous reading of the acoustic impedance of said strip material whereby the desired pressure variation to be applied to said rollers is indicated.

5. Apparatus for processing a strip of damping material to a uniform acoustic impedance comprising, in combination, a calender having a pair of pressure rollers, means for readily varying the pressure between said rollers whereby the acoustic impedance of said material is controlled, means for driving said rollers at a constant rate, means enclosed within said rollers for producing a uniform heat along the surfaces of said rollers, means associated with said calender for maintaining a uniform tension across said strip as it enters said rollers, a take-up mechanism for said strip comprising a take-up spool and a drive pulley, a friction belt coupling said drive pulley and said roller driving means, means associated with said take-up mechanism for adjusting the tension on said belt, said take-up mechanism tending to draw said strip from said rollers at a rate faster than the rate provided by said rollers whereby a constant tension is maintained on said strip as it leaves said rollers, means for passing a known acoustic signal through said calendered and tensioned strip, means for translating said acoustic signal into an electrical signal, and means for measuring said electrical signal to determine the relative acoustic impedance of said strip of material to the passage of said known signal whereby the pressure to be applied between said rollers is indicated.

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