Sept. 10, 1957 F. N. ROTHACKER 2,806,204

DIELECTRIC GAGE

Filed July 20, 1951 2 Sheets-Sheet 1

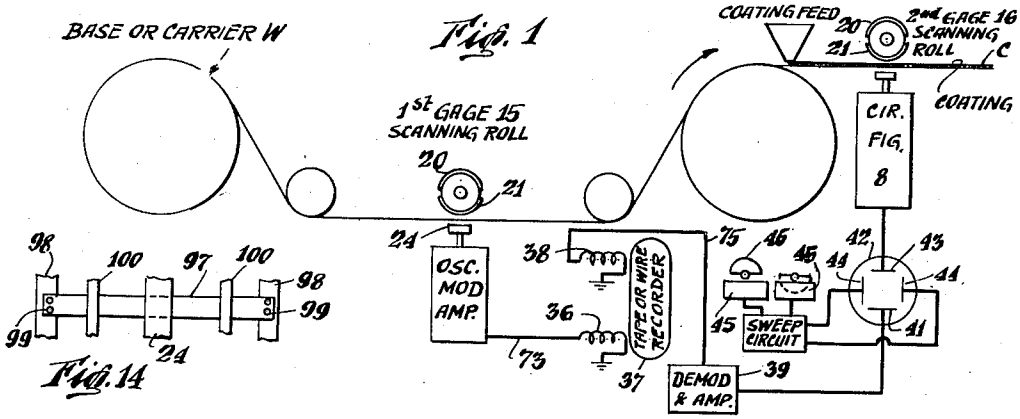



Fig. 1



Fig. 1A

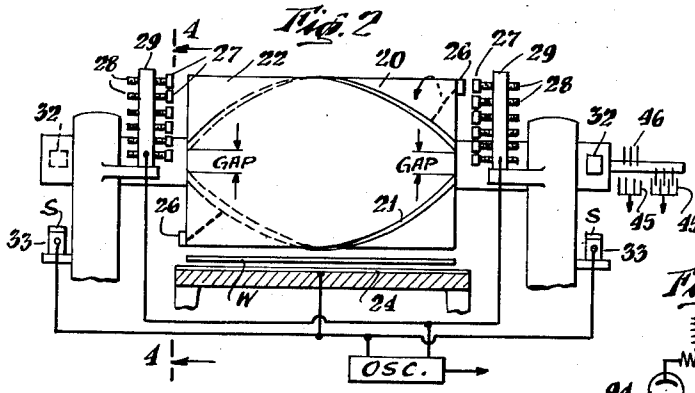



Fig. 2

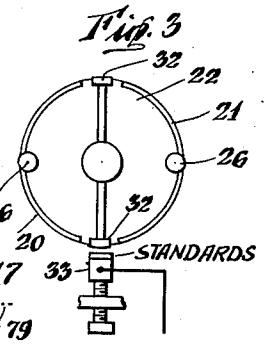



Fig. 3

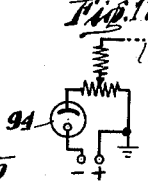


Fig. 17

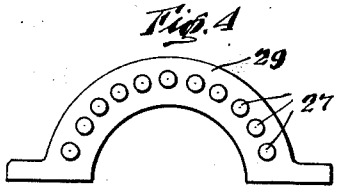


Fig. 4

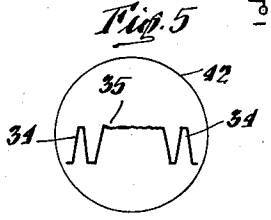


Fig. 5

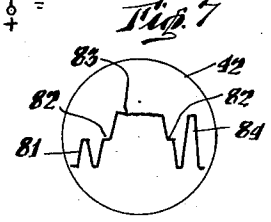


Fig. 7

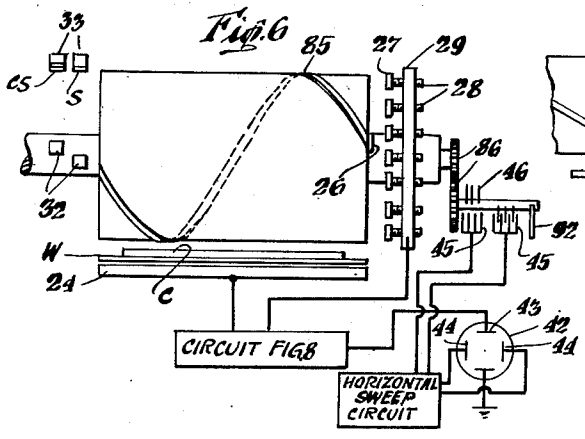



Fig. 6

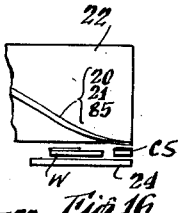


Fig. 16

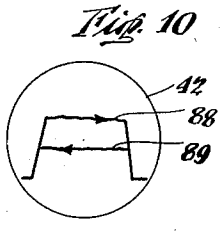


Fig. 10

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DIELECTRIC GAGE

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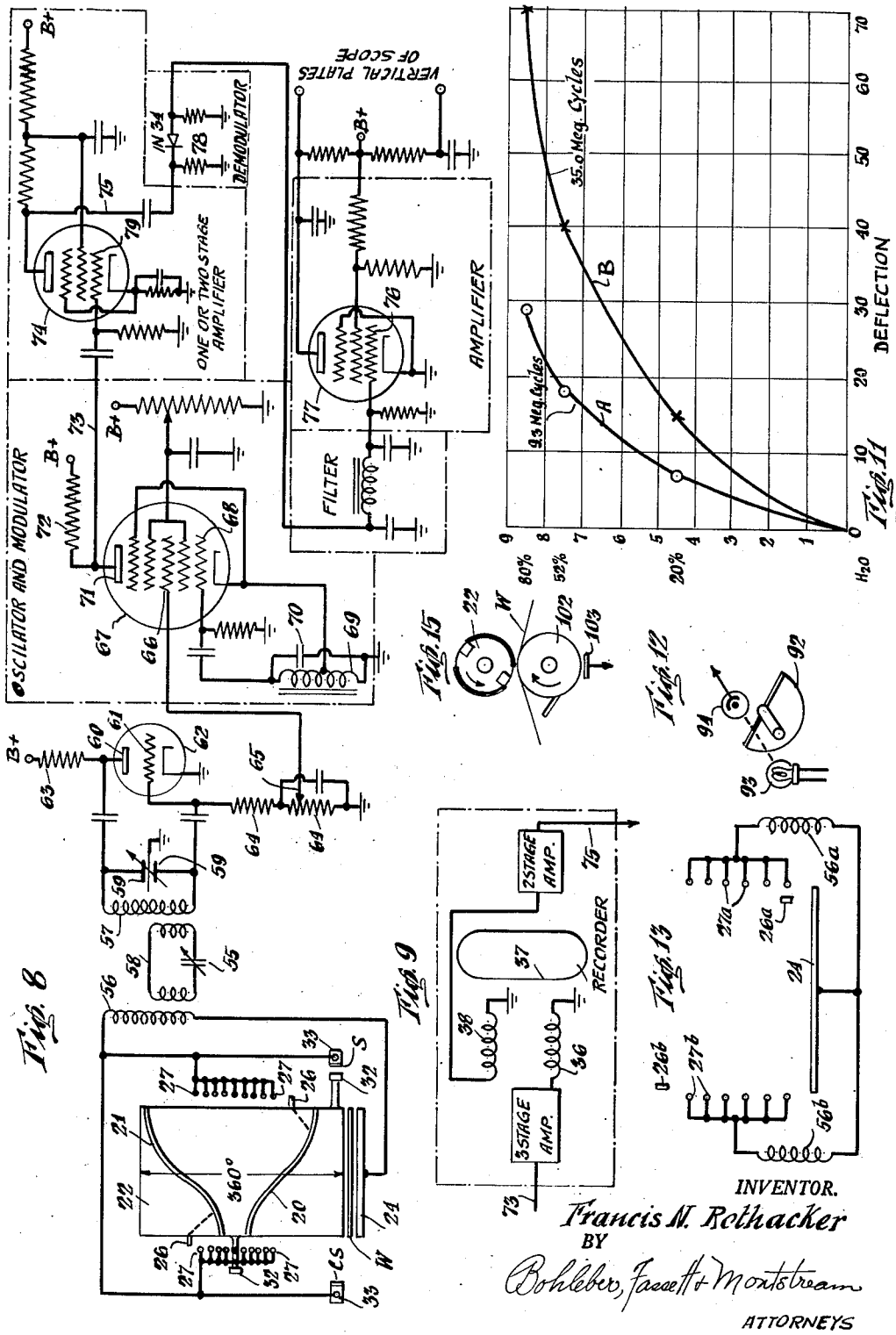



Fig. 8

Fig. 9

Fig. 11

Fig. 12

Fig. 13

Fig. 15

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2,806,204

# DIELECTRIC GAGE

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Application July 20, 1951, Serial No. 237,705

31 Claims. (Cl. 324—61)

The invention relates to a gage applicable to many fields. It will be particularly described herein in connection with the continuous measurement and indication of the thickness of paper or of a coating upon a carrier sheet or web such as of paper or measures both the thickness of the carrier and the coating thereupon. The gage is capable of measuring the thickness of conducting or metallic sheets as well as sheets of dielectric materials. In a somewhat different form it will indicate the moisture content of a continuous web of material.

It is an object of the invention to produce a gage for continuously measuring and indicating any variation in the dielectric value of sheet material and hence of the thickness thereof.

Another object is to construct a gage which continuously measures and indicates the dielectric value of a coating upon a carrier or sheet material and hence of the thickness thereof.

Another object is to construct a gage for continuously measuring and indicating the dielectric value of and hence the thickness of the sheet carrier and of the combined thickness of the carrier and of a coating thereon.

A still further object is to measure the dielectric value of and hence the thickness of a sheet carrier at a first point and to measure the dielectric value of and hence the combined thickness of the carrier and a coating thereupon at a point spaced from the first point and to subtract the first measurement or indication from the second to give a measurement and indication of the thickness of the coating.

Another object is to construct a gage which indicates the dielectric value of and hence the thickness of a sheet material and provides a continuous comparison thereof with one or more standards thereof.

Another object is to continuously indicate the moisture content of a web or sheet of material by a new and novel mechanism.

Other objects of the invention will be more apparent from the following description when taken in connection with the accompanying drawing illustrating some preferred embodiments thereof in which:

Figure 1 is a view of a coating machine with the dielectric gage diagrammatically illustrated in connection therewith;

Figure 2 is an enlarged side view of a scanning roll, capacitive adjusting means and standard comparator means in position for indicating thickness of sheet.

Figure 3 is a diagrammatic end view of a scanning roll and the comparator means in comparator indicating position;

Figure 4 is an enlarged view of the capacitive adjusting means;

Figure 5 is a view of the signal or beam trace on the cathode ray tube;

Figure 6 is a side view of a scanning roll having a single spiral scanning bar, the circumferential dimension of which is a little less than 360°;

Figure 7 is a view of the trace on the cathode ray tube for a coating which does not extend completely across the width of the carrier sheet or paper;



Figure 8 is a diagrammatic view of the circuit for controlling vertical deflection of a scope;

Figure 9 is a circuit diagram of that portion of the circuit for vertical deflection of the indicator or scope having signal delaying means;

Figure 10 is a view showing the trace when the dielectric gage is used to determine thickness and moisture content of a sheet of material utilizing two frequencies;

Figure 11 is a chart for determining the thickness and moisture content of a web from the scope trace;

Figure 12 shows diagrammatically a black-out means for the cathode ray tube for alternate revolutions of the scanning roll of Figure 6;

Figure 13 shows the scanning elements for a gage for gaging thickness and moisture content of a web of material;

Figure 14 is a partial view of the fixed bar **24** support for major adjustment thereof:

Figure 15 is a diagrammatic view of a roller type fixed gaging means;

Figure 16 shows diagrammatically, the scanning gaging means and the fixed gaging means serving as the comparator means; and

Figure 17 is a view of a photo cell blanking circuit.

There is shown diagrammatically in Figure 1 a coating machine in which a carrier or web W, such as paper or cloth, has spread over the face thereof a coating of any material, such as a plastic in the manufacture of linoleum, a plastic coated paper and the like. The gage is also shown more or less diagrammatically as applied to the coating machine.

The carrier or web W to be coated and gaged is fed through a first gaging stage or gage **15** which gages the dielectric value of and hence the thickness thereof after which the coating is applied to the carrier and the coated web or sheet is fed through a second gaging stage or gage **16** which gages the combined dielectric value of and hence the thickness of the carrier and the coating. In the construction and operation of this form of the gage, it is desired to make a gage for continuously gaging or indicating the thickness of the coating upon the carrier. Briefly this is accomplished by gaging the thickness of the carrier or web, recording the signal thereof and later reproducing the same to introduce a fixed delay in its application to an indicator determined by the time for the carrier to travel between the first gaging stage or gage to the second gaging stage or gage after which the first signal is in effect subtracted from the second so that the indicator shows the thickness of the coating. If it is not in accordance with a predetermined desired thickness or standard then the coating feed may be adjusted to correct the same.

The gage includes capacitive means between which the material to be gaged, passes and as it passes a continuous measurement of its dielectric value and hence thickness is secured by continuously measuring the capacitance and any variation in capacitance between what is in effect the plates of a condenser. Many materials may be gaged; however, the description herein will be directed principally to a sheet material constituting a carrier or web W which is coated or being coated. Variation in the thickness of the carrier or sheet material results in a variation of the dielectric value of the same and in turn varies the capacity between the plates of the condenser or capacitive means. Since a sheet or coating may vary across the width thereof, a small area is measured across the width thereof and since it is taken as the carrier is moving at high speed this gaged area crosses the carrier at an angle with respect to the edge thereof.

The capacitive means includes a straight capacitive or conductive gage member, shown as a fixed gage bar **24**, although it may be a metal covered roller, adjacent or underneath scanning roll and spiral scanning gage bar means carried thereby as will be described. The two parts of the capacitive means are spaced apart so that the material, carrier or web passes therebetween. The spacing should be great enough too so that the double thickness of an over-lapping edge which secures together the end of one carrier and the beginning of another carrier may pass therebetween. Bars having a width of about ¼ inch have been used and the width may vary quite widely. The spiral gage bars have a circumferential dimension of less than 180° so that there is a gap, a two inch gap has been used, between the ends of the scanning bars. The scanning bar or roll may be rotated at any desired speed; however, the greater the speed the more readings and closer spaced readings are secured. The higher the speed of the web, the faster the scanning roll must rotate in order to secure the same spacing between readings. For example with the carrier running at 150 feet per minute and the two bars scanning roll turning at 60 revolutions per minute, the readings are about one and a quarter feet apart.

The capacitive means also includes a spiral scanning means or scanning gage bar means which in the construction of Figure 2 includes at least one scanning gaging bar although in the construction particularly illustrated a plurality of such spiral scanning bars are used there being illustrated two such gaging bars **20** and **21**. The spiral form is used so that a relatively short or small area of bar is adjacent the fixed gaging means or bar which area constitutes the gaging area and as the spiral bar rotates the gaging area moves from one edge of the carrier across the other edge. The scanning gage bars **20** and **21** are insulated in any suitable manner such as by being secured to, set in or molded into a scanning roll **22** of insulating material. The scanning gage bars extend somewhat less than 180° around the circumference of the roll and have a gap between the ends of the two scanning bars the purpose of which will be explained hereinafter. If desired, one gaging bar may spiral in a reverse direction from the other as shown so that as they rotate a scanning trace is obtained at an angle across the sheet from one edge to the other edge and then at an angle from that side or edge back to the first edge.

The spiral scanning means and hence the capacitive means preferably includes also means or mechanism to accurately adjust the capacity between the gage bars throughout their length. This means may take many forms. That illustrated includes a conducting means, shown as a separate member **26** although a simpler form is the end of the scanning bar as shown in Figure 6, and a second conducting means comprising a plurality of conducting members **27** each of which has adjusting means in the form of a screw **28**. Twenty-eight of the conducting members **27** have been used for each of the two scanning gage bars and the area thereof has a wide range. A round member **27** of about ½" in diameter will provide sufficient adjustment. The conducting means formed by the plurality of conducting members **27** have a circumferential extent corresponding to that of the spiral gage bar. With two spiral scanning gage bars as illustrated there is for each such gage bar, a rotating conducting member **26** and a plurality of circumferentially spaced and fixed conducting members **27** having adjustable means for each member for adjusting the position thereof. One of the conducting or adjustable capacitive means, either the plurality or the single one, is rotatable with the roller and may be carried thereby as shown, and the other conducting means is fixed. In the construction particularly illustrated the single conducting member **26** is mounted to be rotated with the roller or scanning bar and its simplest form is to bend



the end of the scanning bar over the end face of the roller as shown in Figure 6. The conducting means comprising the plurality of adjustable capacitive or conducting members **27** are carried by a frame **29** which is fixed to some part of the frame of the gage. This construction provides one which is more convenient to adjust.

The adjustable capacitive means or mechanism is used to adjust the capacity between the scanning bar or bars and the fixed bar throughout the length thereof. The signal developed between the gage bars is irregular irrespective of how carefully the radial dimension of the scanning bar is ground and how carefully the fixed bar is made. The safer way to secure adjustment is to space each adjustable capacitive member **27**, five thousandths of an inch from the conducting or capacitive member **26**. The members **27** are then backed away in order to straighten out the beam trace on the scope indicator. The scanning bar or roll is rotated therefore and the signal noted on the indicator. If a high spot of capacity is indicated by the signal or trace on the scope, the adjusting screw **28** for the proper conducting member **27** is adjusted or backed away until the beam indicates a uniform level. When the signal or trace shows a constant or practically a constant level of capacity it will be properly adjusted. There will be some ripple or peaking as the scanning bar is rotated with respect to the fixed bar **24** because of the adjusting capacitance **27**; however, this is desirable because when making the initial adjustment the peaks may be counted on the scope and thereby determine which adjusting capacity is out of adjustment. One such capacitive adjusting mechanism or means is provided for each scanning bar and the one shown on the left of Figure 2 is for the spiral gage bar **20** and the one on the right is for gage bar **21**.

Means or mechanism may be provided to compare the carrier and the coated carrier as to its dielectric value or thickness with respect to a standard sample. This comparing mechanism comprises a rotatable comparator bar **32** which is connected with the scanning bar or roller to be rotatable therewith. It is also located circumferentially in the gap between the ends of the scanning bar or bars. Adjacent to the path of rotation of the comparator bar **32** is a fixed conducting comparator bar **33** upon which is carried a standard sample S. Preferably one such comparator means or pair of comparator bars **32, 33** is provided for each side of the carrier, that is, the two pairs are 180° apart from each other so that a standard pip or signal **34** is obtained at each side of the signal from the carrier or web. If the web such as paper should be thinner than shown by the standard, the signal **35** would have a lower level and the operator would be informed thereby to increase the thickness of the web or to decrease it in the event that the carrier web shows a thickness greater than the standard thickness. Or if the web is not being made at the same time, it would call for adjustment of the signal on the second gage in order to give a true comparison or indication of the thickness of the coating as will be clear where this second gage is described herein.

The capacity between the scanning gage bar and the fixed gage bar, when the carrier or the coated carrier is passed therebetween, is converted into an electric equivalent such as current flow and amplified by any suitable electronic circuit. It is preferred to use an oscillating circuit to effect the conversion and amplification and the circuit will be described more fully hereinafter.

The second gage **16** for the coated section of the carrier or web is identical with the first gage **15** described above excepting that the standard sample for comparison would be a coated sample. This second gage does not use the signal recording portion of the first gage as will be described. The signal from this second gage is applied to a vertical deflection plate of the scope or indicator. This second gage, therefore, need not be described.

There is some distance necessarily between the location of the first gage 15 for gaging the thickness of the carrier or web W and the second gage 16 for gaging the thickness of the coated carrier. In one construction this distance was thirteen feet so that the first gage gages the thickness of the carrier at a position thirteen feet in advance of the gaging taking place of the carrier and coating in the second position between which there may be some variation in carrier thickness. In order to gage the thickness of the coating being applied to the carrier, it is necessary to include a delay means so that the carrier signal is applied to the indicator or scope 42 simultaneously or approximately simultaneously at the time that part of the carrier reaches the second gaging position or at or approximately at thirteen feet after the signal or gaging took place. This has been accomplished by recording the signal from the first gage. The signal is amplified through any suitable electronic circuit as will be described hereinafter and this signal is fed to a recording mechanism 36 which records the signal on a tape or wire 37, an electromagnetic recording mechanism having been used. With the tape or wire recorder traveling at 1/10 the speed of the carrier, after the record tape has travelled 1.3 feet the pick up means 38 takes the signal off of the record or tape so that the signal at the pick up means 38 is taken off just at the time that that portion of the carrier gaged at the first gaging position is under or approximately under the second gaging roll at the second gaging position. An amplifier 39 may amplify the signal from the recorder which amplified signal is applied to one of the pair of vertical deflecting plates of the indicator or cathode ray tube, that is, plate 41. This time delay circuit or mechanism is substituted for the amplifier tube 74 in the circuit of Figure 8.

The signal from the first gage is subtracted from the signal from the second gage, which measures the combined thickness of carrier and coating, so that the resultant signal shown on the indicator is the thickness of the coating. This subtraction of signals is secured by applying the amplifier signal from the pick up mechanism 38 to one vertical beam control means such as the vertical beam control plate 41 of a pair of oppositely disposed vertical control plates of a cathode ray tube 42. The signal from the second gage is applied to the other vertical control means or the other plate 43 of the oppositely disposed pair of the vertical control plates of the cathode ray tube so that the beam control between the plates is that produced by a difference between the amplitude of the signal from the second gage and the signal from the first gage. This resultant field or signal, therefore, is proportional to the thickness of the coating upon the carrier and hence the scope indicates the thickness of the coating C on the carrier or material W.

The other pair of plates 44 of the cathode ray tube are connected with a sweep circuit of any suitable construction, many being well known, to sweep the beam across the tube for each scanning bar. Preferably, however, the sweep circuit includes a condenser having fixed plates 45 and rotating plates 46 cooperating therewith. The rotating plates are driven with the scanning roller so that the beam is swept across the cathode ray tube for one scanning bar and back again at the same speed for the other scanning bar. By driving the rotating condenser plates from the scanning roller or shaft, the sweep is timed therewith. With two scanning gage bars as in the construction particularly shown, one signal will be the beam trace in one direction from one scanning bar and the beam trace in the opposite direction will be the signals from the second scanning gage bar which, however, should be identical and overlap except as to the standard pip if there is no change in thickness and the two scannings are properly adjusted.

The scanning bar may be rotated at any desired speed with respect to the speed of the carrier. The faster that the scanning bar rotates the more readings will be secured of the carrier thickness and the scanning thereacross will be closer together. It is suitable to rotate the scanning cylinder or bars at 60 R. P. M. and if the carrier or web travels at 150 feet per minute, with two scanning bars, readings occur within about one and a half feet lengthwise of the carrier. This is not a limiting dimension and the spacing between the repeat cycles or readings may be anything desired by the manufacturer of the carrier to be measured. In fact a measurement every fifty feet probably gives ample information.

The electronic circuit for converting the capacity between the scanning gage means and the fixed gage means and any variation in capacitance due to the dielectric of the material passing therebetween and the amplification thereof is secured by any suitable operating circuit. The basic circuit particularly illustrated in Figure 8 includes an oscillator amplifier, modulating means, amplifier means, demodulating means, and amplifier means. The entire circuit and the modulation portion or element thereof is introduced primarily because it is a more effective amplifier. A coil 56 is connected at one end to the scanning means, which if adjustable capacitive means 27 are used is connected to this part of the scanning means, and the other end of the coil is connected with the fixed gage means or bar 24. The coil 56 is coupled to coil 57 such as through a coupling coil 58 which may have a condenser 55 in series therewith. The coil 57 has a pair of condensers 59 connected thereacross and the midpoint is connected to the cathode of the tube 62 through ground to form an oscillator. The tank or oscillator circuit 57, 59 is connected between the plate 60 and grid 61 of the tube 62. The plate has a load resistor 63 in series therewith. Resistive means 64 is connected between the grid and ground.

The oscillator generates a frequency such as 5 to 10 megacycles and operates on the slope of the resonance curve and preferably on the high frequency side of the curve. Any variation in capacity between the gage means or bars, due to variations in thickness of the carrier or coated carrier, manifests itself in a variation in the frequency of oscillation generated by the oscillator amplifier, the result of which is to produce a variation in current flow through the resistive means 64. This constitutes what is known as a grid dip meter although it operates as an oscillator it is in effect a sensitive amplifier.

The variations in current through the resistive means 64 result in variations in the voltage at an adjustable contact 65 which is connected with the mixer grid 66 of a modulator tube 67. The grid 68 of the tube is connected with a coil 69 and condenser 70 connected in parallel with each other and forms an oscillatory circuit which generates a frequency of about a thousand cycles. The signal appearing on the grid 66, which is proportional to the dielectric value of the carrier W and the thickness thereof, is used to modulate the thousand cycle oscillation generated by the oscillator circuit of this modulator. The plate 71 of the tube has load resistive means 72 connected therewith and the signal appearing on the plate is transmitted through an output connection or wire 73 to an amplifier, shown as a single stage or tube 74 having a control grid 79. The amplifier may be one or more stages as desired. The tube 74 is biased to pass the negative half of the signal applied to its grid. The output connection 75 of amplifier 74 is connected with the grid 76 of a second amplifier tube 77 through a demodulating means 78 which may be a crystal detector. The output of the tube 77 is connected with a vertical deflecting plate 41 of the indicator or cathode ray tube 42. As previously discussed the pick-up coil 38 of the tape recorder is connected, through amplifier 39, with the other vertical deflecting plate 43 of the indicator or cathode ray tube so that the two signals subtract and hence the beam trace on the cathode ray tube is a running or continuous measurement of the thickness of the coating C on the carrier W. The tube 77 is biased to approximately twenty-five

volts beyond cutoff so that the modulation signal only or approximately this signal is amplified and transmitted to the scope. It represents about 1% of the total voltage applied to the grid resistor of the tube.

If the coating C on the carrier W does not extend completely across the sheet, which is the way the coating is applied thereto in many cases, there is left a short margin of uncoated carrier at each edge of the sheet. With this form of coated carrier it is not necessary to make two separate gage readings nor to provide two gages since a single gage will give all the necessary information. In such case, the gage may be the same as the second gage **16** with the output of the amplifying means connected with the vertical deflecting means or plate **43** of the cathode ray tube **42**, and the other vertical deflecting means or plate **41** is grounded in the manner shown in Figure 6. In this case one scanning gage bar **20** or **85** alone need be provided and one of the standards carried by one of the conductors **33** may be a coated standard. The trace formed upon the screen of the cathode ray tube **42** would be that shown in Figure 7 where a pip **81** is that produced by the paper standard for comparison with the level or land **82** in the trace which constitutes the measurement of the paper thickness at one edge of the carrier. The land **83** is the measurement or indication of the coated carrier after which appears a second land or level **82** which is the thickness of the paper at the other edge of the carrier W and finally a pip **84** which is the thickness of the coated standard for comparison with the thickness of the coated carrier represented by the land or level **83**. The beam may be blacked out in any way as is well known, upon the return pass thereof; however, such black out need not be provided in which case the beam provides a trace at the lowest level. The circumferential gap of over 180° between the ends of one scanning edge bar gives the same amount of time for the beam to return to the initial side of the cathode ray scope under the control of the rotating condenser means **45**, **46**.

The gage for a carrier or web W having a coating C thereon spaced from the edge of the carrier may use the scanning roller of Figure 6 in which a single spiral scanning gaging bar **85** is used. With this form of scanning bar the horizontal sweep circuit may be of usual form which generates a saw-tooth sweep signal which provides a rapid beam return. The horizontal sweep circuit may include a condenser **45**, **46** having plates **45** rotated with the scanning roll at half the speed of the scanning roll by gears **86** in which case the horizontal traverse of the beam across and back is uniform. It may be desirable to have alternate revolutions of the scanning roll provide a scanning trace on the scope and a blackout means may be used to black out the return trace in the inbetween alternate revolutions. Such blackout means may take many forms there being shown in Figure 12, a half disc **92** driven at half of the speed of the scanning roll, and hence may be mounted on the shaft with the rotating condenser plates **45** of Figure 6. With a light source **93** on one side thereof and a photocell **94** on the other side so that the light beam plays on the photocell for alternate revolutions, the light beam is cut off for the inbetween alternate revolutions. The photocell is connected in the grid circuit of the control grid of one of the tubes, such as the amplifier tube **74**, as illustrated in Figure 17, to drive the grid bias to cut off in one of the conditions or positions of the half disc.

The gage may be used to measure or indicate the moisture content and thickness of a web of material such as paper, cloth and the like. It has been found that applying high frequency oscillations to the sheet of two different frequencies, that the magnitude of signal or response for each frequency is different for the same degree or amount of moisture and that the magnitude is different for different amounts of moisture. Figure 11 is a chart or plot of the magnitude of deflection at two different frequencies and at different conditions of moisture content. Curve A is the deflection of the beam of a cathode ray tube at 9.3 megacycles applied oscillation and curve B at 35.0 megacycles. For different applied frequencies a different pair of curves must be plotted. The frequency or frequencies used for reliable results should have a ratio of at least 1 to 2 and the greater the ratio the more accurate are the results achieved. A ratio of 5 megacycles for one frequency and 20 to 30 megacycles for the other appears best.

For moisture and thickness gaging, the mechanism of Figure 1 and the circuit of Figures 8 and 9 may be used, each gage generating a different oscillation frequency applied to the scanning gage bars or generated by the first tube. A simpler construction is shown in Figure 13 where each scanning bar or its adjusting capacitive means **27***a* and **27***b* is connected to a separate coil **56***a* and **56***b* and each coil has the circuit of Figure 8 connected thereto which are alike except that one circuit applies one high frequency to the wet web to be gaged and the other coil applies a different high frequency such as those referred to above. The output of one of the two circuits is applied to the vertical deflecting plate **43** of the cathode ray tube **42** and the output of the other circuit is connected with the other vertical deflecting plate **41** and the trace is shown in Figure 10 from which the difference in amplitude is read directly by the space between traces. The difference between traces is applied to the chart of Figure 11 horizontally between curve A and curve B and wherever this difference lies, the moisture content of the web is read from the left hand percent moisture indicia. The thickness of the sheet or web is determined by reading the level of the horizontal portion of the trace for either the high or low frequency and locating the same on the curve for its respective frequency and reading the thickness from the thickness indicia on the left margin of the chart.

The fixed gage or condenser bar may be mounted in position in any suitable manner; however, it is desirable to so mount it that its spacing with the scanning roll may be given primary adjustment at various points in its length. Figure 14 illustrates one form of such adjusting means in that at spaced intervals the fixed bar **24** is secured to a cross member **97** which may be of insulating material which cross member is secured at each end to a rail **98** extending the length of the scanning cylinder by screw adjustment **99** which raises and lowers the cross member with respect to the rail and hence raises and lowers the fixed bar **24**. Spacer bars **100** may be provided to retain the sheet or web above the fixed gage bar **24** so that the fixed bar will not be worn by contact with the carrier or web.

The fixed gaging means **24** may be a roller **102** as in Figure 15 if desired which because of its curvature has a capacitive effect similar to the straight stationary bar **24**. The roller may be of thin metal mounted on an insulated roller or of solid metal, or hollow metal and is rotated at a peripheral speed the same as the carrier speed. Preferably it rotates at the same speed as the scanning roll **22**. A connection may be made with the roller form of fixed gaging means by direct connection therewith; however, a capacitive connection is preferred through a fixed bar **103** mounted adjacent thereto and extending the length thereof.

An end or both ends of the scanning bar gaging means and the fixed gaging means **24** may extend beyond the end of the web or carrier being gaged and be used as the standard gaging means as shown in Figure 16. A standard coated carrier CS may be placed or retained above one projecting or lengthened end of the fixed gage bar **24** and is scanned by the extended end of the scanning bar **20**. The other end may likewise be extended or lengthened beyond the carrier and used in the same manner with an uncoated sample to proved a constant comparator means for the web or carrier W. The scope trace would be the same as that shown in Figure 7.

The gage is effective for thread, painted surfaces, plating, and steel sheets which demonstrates its wide applicability. Since moisture affects the dielectric value, any material which picks up moisture should be gaged in a room or surroundings which are humidified to keep the atmospheric moisture conditions constant. If it is desired to determine moisture content as well, the use of two different frequencies may be used in the manner described.

The conducting member **26** and each of the adjustable conducting members **27** are means for electrically connecting the electronic circuit, such as by capacitively coupling, with the scanning bar means **20, 21** to the electronic circuit and fixed gaging means as well as providing, when adjustable, as shown, adjustable capacitance for the scanning bar means. The spiral scanning bar also provides a simple means for providing a capacitive means or area which moves across the width of the web or material passing between the gaging means.

The gage for indicating moisture content and thickness of a moisture absorbing material or web provides also a new method of gaging these factors in such material. These facts are gaged quickly, easily and continuously by applying two different high frequencies to the material or web each of which frequencies responds differently to the moisture in the material. The difference in the response of the material at the two frequencies is then compared with previously determined differences in response of samples of the same material and of known moisture content enables the content to be quickly determined or read from a chart such as Figure 11. The level of response of either frequency when compared with a standard previously determined and recorded such as the curves on the chart give the thickness of the material.

The capacitive adjusting means for the gaging bars **20, 24** formed by the conducting member **26** and the plurality of conducting members **27** is shown connected with, such as by capacitive coupling, the scanning gaging bar. The plurality of adjustable conducting members may be connected with either gage bar since it is immaterial which of the gage bars has its capacity modified or adjusted in order to adjust the capacity between bars, and the rotating conducting member **26** serves as a commutator to coact with the proper adjusted conducting member **27**. The conducting members **27** in being connected to the scanning bar end of the coupling coil, serve two functions for which otherwise separate elements must be provided for each function. The two functions are first they provide a connecting or capacitive coupling means with the rotating scanning bar and secondly by breaking the means up into separate members and adjusting each member, the members provide adjustable capacitive means for the capacity between the two gaging bars or means. Also each adjustable conducting member in effect provides a series of spot readings across the width of the material or scanning bar by each peak observed on the cathode ray tube or scope for each adjustable member which peak enables an installer to quickly determine by counting peaks to any high peak or peaks, the adjustable member which gave that high peak and hence needs adjusting.

This invention is presented to fill a need for improvements in a dielectric gage. It is understood that various modifications in structure, as well as changes in mode of operation, assembly, and manner of use, may and often do occur to those skilled in the art, especially after benefiting from the teachings of an invention. Hence, it will be understood that this disclosure is illustrative of preferred means of embodying the invention in useful form by explaining the construction, operation and advantages thereof.

What is claimed is:

1. A gage to measure variations in a material comprising capacitive means including a fixed gaging means of substantial length and scanning gaging bar means of spiral form mounted for rotation adjacent the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic amplifying circuit connected with the scanning gaging bar means and the fixed gage bar responsive to the capacity between the means due to the material passing therebetween, indicator means connected with the electronic circuit to indicate variations in capacity between the gaging means due to variations in the material passing therebetween, capacitive adjusting means comprising a plurality of circumferentially spaced conducting members, adjusting mechanism for each member, and a circumferentially short conducting means, one of said means being connected with the scanning bar means for rotation therewith and electrically connected therewith, and the other means being fixed adjacent the path of rotation of the rotatable means and electrically connected with the fixed gaging bar means.

2. A gage to measure variations in a material comprising capacitive means including a fixed gaging means of substantial length and scanning gaging bar means of spiral form mounted for rotation adjacent the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic amplifying circuit connected with the scanning gaging bar means and the fixed gage bar responsive to the capacity between the means due to the material passing therebetween, indicator means connected with the electronic circuit to indicate variations in capacity between the gaging means due to variations in the material passing therebetween, capacitive adjusting means for each spiral scanning bar means comprising a circumferentially short conducting member connected with each scanning bar means for rotation therewith and electrically connected therewith, and a plurality of circumferentially spaced adjustable members for each scanning bar mounted adjacent to the path of rotation of the rotating conducting member and electrically connected with the fixed gaging means.

3. A gage to measure variations in a material comprising capacitive means including a fixed gaging means of substantial length and scanning gaging bar means of spiral form mounted for rotation adjacent the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic amplifying circuit connected with the scanning gaging bar means and the fixed gage bar responsive to the capacity between the means due to the material passing therebetween, indicator means connected with the electronic circuit to indicate variations in capacity between the gaging means due to variations in the material passing therebetween, at least one standard comparator mechanism comprising a rotatable comparator bar of short circumferential dimension and connected with the scanning bar means for rotation therewith and located in a circumferential gap of the scanning bar means; a fixed comparator bar of short circumferential dimension located to be passed by the rotatable comparator bar as it rotates, and means connecting the comparator bars with the electronic circuit.

4. A gage to measure variations in a material comprising capacitive means including a fixed gaging means of substantial length and scanning gaging bar means of spiral form mounted for rotation adjacent the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic amplifying circuit connected with the scanning gaging bar means and the fixed gage bar responsive to the capacity between the means due to the material passing therebetween, indicator means connected with the electronic circuit to indicate variations in capacity between the gaging means due to variations in the material passing therebetween, adjustable capacitive mechanism for each spiral scanning bar comprising a first conducting means, and a second means including a plurality of circumferentially spaced conducting members, adjusting mechanism for each conducting member to adjust the position thereof towards and away from the first conducting means, one of said means being connected with the scanning gage bar means for rotation therewith and electrically connected therewith, and the

other means being fixed adjacent the path of rotation of the rotating means and electrically connected with the fixed gaging bar; at least one standard comparator mechanism comprising a rotating comparator bar of short circumferential dimension connected with the scanning gage bar means for rotation therewith and located in a circumferential gap of the scanning gage bar means, a fixed comparator bar of short circumferential dimension located to be passed by the rotatable comparator bar as it rotates, and means electrically connecting the comparator bars with the electronic circuit.

5. A gage to measure variations in a material comprising capacitive means including a fixed gaging means of substantial length and scanning gaging bar means of spiral form mounted for rotation adjacent the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic amplifying circuit connected with the scanning gaging bar means and the fixed gage bar responsive to the capacity between the means due to the material passing therebetween, indicator means connected with the electronic circuit to indicate variations in capacity between the gaging means due to variations in the material passing therebetween, adjustable capacitive means comprising a plurality of circumferentially spaced conducting members, adjusting mechanism for each member, and a circumferentially short conducting means, one of said means being connected with the scanning gage bar means for rotation therewith and electrically connected therewith, and the other means being fixed adjacent the path of rotation of the rotating means and electrically connected with the fixed gaging bar; and a plurality of comparator mechanisms each comprising a rotating comparator bar of short circumferential dimension connected with the scanning gage bar means for rotation therewith and located in a circumferential gap of the scanning gage bar means, a fixed comparator bar of short circumferential dimension located to be passed by the rotatable comparator bar as it rotates, and means electrically connecting the fixed comparator bars with the electronic circuit.

6. A gage to measure variations in a material comprising capacitive means including a fixed gaging means of substantial length and scanning gaging bar means of spiral form mounted for rotation adjacent the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic amplifying circuit connected with the scanning gaging bar means and the fixed gage bar responsive to the capacity between the means due to the material passing therebetween, indicator means connected with the electronic circuit to indicate variations in capacity between the gaging means due to variations in the material passing therebetween, capacitive adjusting mechanism for the scanning bar means comprising a circumferentially short conducting member connected with each scanning bar for rotation therewith and electrically connected therewith, a plurality of circumferentially spaced conducting members for the scanning bar means and mounted adjacent to the path of rotation of the short conducting member, and electrically connected with the fixed gaging bar, means to adjust the position of each circumferentially spaced member, at least one standard comparator mechanism comprising a rotatable comparator bar of short circumferential dimension and connected with the scanning bar means for rotation therewith and located in a circumferential gap of the scanning bar means, a fixed comparator bar of short circumferential dimension located to be passed by the rotatable comparator bar as it rotates, and means electrically connecting the comparator bar with the electronic circuit.

7. A gage to measure variations in a material comprising capacitive means including a fixed gaging means and scanning gaging means having a plurality of gage bars of spiral form and each bar being circumferentially spaced from the other scanning gage bar, means mounting the scanning gage bars for rotation adjacent to the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic circuit connected with the scanning gage bar means and the fixed gaging means responsive to the capacity between the gage bars due to the material passing therebetween, and indicator means connected with the electronic circuit to indicate the capacity between the capacitive means due to the material passing therebetween; the indicator means being a cathode ray tube, and horizontal sweep means for the cathode ray tube including a condenser having plates rotatable with the scanning bars and controlling the sweep of the beam.

8. A gage to measure variations in a material comprising capacitive means including a fixed gaging means and scanning gaging means having a plurality of gage bars of spiral form and each bar being circumferentially spaced from the other scanning gage bar, means mounting the scanning gage bars for rotation adjacent to the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic circuit connected with the scanning gage bar means and the fixed gaging means responsive to the capacity between the gage bars due to the material passing therebetween, and indicator means connected with the electronic circuit to indicate the capacity between the capacitive means due to the material passing therebetween; capacitive adjusting mechanism for each scanning bar comprising adjusting means including a plurality of circumferentially spaced adjustable members, and a circumferentially short conducting means, one of said means being connected with the scanning bar for rotation therewith and the other means being fixed adjacent the path of rotation of the means which is rotatable, and the rotatable means being electrically connected with the spiral scanning bar and the fixed means being electrically connected with the fixed gaging bar.

9. A gage to measure variations in a material comprising capacitive means including a fixed gaging means and scanning gaging means having a plurality of gage bars of spiral form and each bar being circumferentially spaced from the other scanning gage bar, means mounting the scanning gage bars for rotation adjacent to the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic circuit connected with the scanning gage bar means and the fixed gaging means responsive to the capacity between the gage bars due to the material passing therebetween, and indicator means connected with the electronic circuit to indicate the capacity between the capacitive means due to the material passing therebetween; capacitive adjusting means for each spiral scanning bar comprising a circumferentially short conducting member rotatable with each scanning bar, and a plurality of circumferentially spaced adjustable members for each scanning bar and mounted adjacent to the path of rotation of the short conducting member, the conducting member being electrically connected with the scanning bar and the circumferentially spaced adjustable members being electrically connected with the fixed bar.

10. A gage to measure variations in a material comprising capacitive means including a fixed gaging means and scanning gaging means having a plurality of gage bars of spiral form and each bar being circumferentially spaced from the other scanning gage bar, means mounting the scanning gage bars for rotation adjacent to the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic circuit connected with the scanning gage bar means and the fixed gaging means responsive to the capacity between the gage bars due to the material passing therebetween, and indicator means connected with the electronic circuit to indicate the capacity between the capacitive means due to the material passing therebetween; a circumferential gap between each scanning gage bar including at least one standard comparator mechanism comprising a rotatable

comparator bar of short circumferential dimension and connected with the scanning bar for rotation therewith and located in a circumferential gap between the scanning bars; a fixed comparator bar of short circumferential dimension located to be passed by the rotatable comparator bar as it rotates, and means connecting one of the comparator bars with the electronic circuit.

11. A gage to measure variations in a material comprising capacitive means including a fixed gaging means and scanning gaging means having a plurality of gage bars of spiral form and each bar being circumferentially spaced from the other scanning gage bar, means mounting the scanning gage bars for rotation adjacent to the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic circuit connected with the scanning gage bar means and the fixed gaging means responsive to the capacity between the gage bars due to the material passing therebetween, and indicator means connected with the electronic circuit to indicate the capacity between the capacitive means due to the material passing therebetween; capacitive adjusting mechanism for each spiral scanning gage bar comprising adjusting means including a plurality of circumferentially spaced adjustable members, and a circumferentially short conducting means, one of said means being connected with its scanning bar for rotation therewith and the other means being fixed adjacent the path of rotation of the rotatable means, and the rotatable means being electrically connected with the spiral scanning bar and the fixed means being electrically connected wtih the fixed gaging bar, at least one standard comparator mechanism comprising a rotatable comparator bar of short circumferential dimension and connected with the scanning bar for rotation therewith and located in a circumferential gap between the scanning bars, a fixed comparator bar of short circumferential dimension located to be passed by the rotatable comparator bar as it rotates, and means electrically connecting the fixed comparator bar with the electronic circuit.

12. A gage to measure variations in a material comprising capacitive means including a fixed gaging means and scanning gaging means having a plurality of gage bars of spiral form and each bar being circumferentially spaced from the other scanning gage bar, means mounting the scanning gage bars for rotation adjacent to the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic circuit connected with the scanning gage bar means and the fixed gaging means responsive to the capacity between the gage bars due to the material passing therebetween, and indicator means connected with the electronic circuit to indicate the capacity between the capacitive means due to the material passing therebetween; capacitive adjusting mechanism for each scanning bar including a circumferentially short conducting member rotatable with each scanning bar, a plurality of circumferentially spaced members for each scanning bar and mounted adjacent to the path of rotation of the short conducting member, the conducting member being connected with the scanning bar and the circumferentially spaced members being electrically connected with the fixed bar, means to adjust the position of each circumferentially spaced member, at least one standard comparator mechanism comprising a rotatable comparator bar of short circumferential dimension and connected with the scanning bar for rotation therewith and located in a circumferential gap of the scanning bar, a fixed comparator bar of short circumferential dimension located to be passed by the rotatable comparator bar as it rotates, and means electrically connecting a comparator bar with the electronic circuit.

13. A gage to measure variations in a coating upon a material comprising a first gage, the first gage including a fixed gage bar, at least one scanning gage bar means of spiral form mounted for rotation adjacent the fixed gage bar and spaced therefrom to pass a material therebetween, and an electronic circuit connected with the scanning gage bar means and the fixed gage bar responsive to the capacity therebetween due to the material passing therebetween, the electronic circuit including time delay means; and a second gage adapted to be spaced along the material from the first gage thereby resulting in a spaced timing in their readings, the second gage including a fixed gage bar, at least one scanning gage bar means of spiral form mounted for rotation adjacent the fixed gage bar and spaced therefrom to pass a material therebetween, and an electronic circuit connected with the scanning gage bar means and the fixed gage bar responsive to the capacity between the gage bars due to the material passing therebetween; and a cathode ray tube having beam deflecting means with the electronic circuit of each gage connected to the beam deflecting means in subtractive relation to indicate the thickness of the coating on the material.

14. A gage as in claim 13 in which the beam deflecting means of the cathode ray tube are oppositely disposed plates, and the electronic circuit for one gage being connected with one plate, and the electronic circuit for the other gage being connected with the other plate.

15. A gage as in claim 13 in which the time delay means is a recording mechanism having recording means and pick up means, spaced from the recording means, and the spacing therebetween providing a time delay equal to the spaced time between the readings of the two gages.

16. A gage to measure variations in a material comprising capacitive means including a fixed gaging means and scanning gaging bar means of spiral form mounted for rotation adjacent the fixed gaging means and spaced therefrom to pass a material therebetween and having a continuous circumferential extent of approximately 360°, an electronic amplifying circuit connected with the scanning gaging bar means and the fixed gage bar responsive to the capacity between the means due to the material passing therebetween, a cathode ray tube indicator connected with the electronic amplifying circuit to indicate variations in the capacity between the capacitive means due to variations in the material passing therebetween and having horizontal sweep means for the beam, and a sweep circuit connected with the tube indicator sweep means including a pair of sets of condenser plates connected with the scanning gaging bar means to be rotated thereby at twice the speed of rotation thereof and a pair of sets of fixed plates mounted for cooperation with the rotatable condenser plates.

17. A gage as in claim 16 including capacitive adjusting means for the spiral scanning bar means comprising a circumferentially short conducting member connected with the scanning bar means for rotation therewith and electrically connected therewith, and a plurality of circumferentially spaced adjustable members mounted adjacent to the path of rotation of the rotating conducting member and electrically connected with the fixed gaging means.

18. A gage as in claim 16 including blanking means driven by the scanning gaging bar means and connected in the electronic circuit to blank out the return beam trace on the cathode ray tube.

19. A gage as in claim 18 in which the blanking means is a photoelectric cell, a lamp directing its light upon the cell, and a blanking plate driven with the condenser means and obstructing the light between the lamp and photocell for alternate revolutions of the scanning gaging bar means.

20. A gage as in claim 16 including capacitive adjusting means for the spiral scanning bar means comprising a circumferentially short conducting member connected with the scanning bar means for rotation therewith and a plurality of circumferentially spaced adjustable members mounted adjacent to the path of rotation of the rotating conducting member and electrically connected

with the fixed gaging means; and blanking means driven by the scanning gaging bar means and connected in the electronic circuit to blank out the return beam trace on the cathode ray tube.

21. A gage to measure variations in a material comprising capacitive means including a fixed gaging means and scanning gaging means having a pair of scanning gage bars of spiral form and each bar being circumferentially spaced from the other scanning gage bar, means mounting the scanning gage bars for rotation adjacent to the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic circuit connected between each scanning bar and the fixed gaging means including an oscillator for each circuit generating a high frequency, the frequency generated by the oscillators having a ratio of at least two to one; and indicating means connected with the electronic circuits.

22. A gage as in claim 21 in which the indicating means is a cathode ray tube having vertical deflecting means and horizontal deflecting means, beam sweep means connected with the horizontal deflecting means, and the electronic circuits connected with the vertical deflecting means of the cathode ray tube.

23. A gage as in claim 21 including capacitive means connected with the scanning bar means and driven therewith and forming a part of the sweep circuit to synchronize the sweep of the beam with the rotation of the scanning means.

24. A gage to measure variations in a material comprising capacitive means including a fixed gaging means and scanning gaging means having at least one scanning gaging bar of spiral form, means mounting the scanning gaging bar for rotation adjacent to the fixed gaging means and spaced therefrom to pass a material therebetween; an electronic circuit connected with the scanning gaging means and the fixed gaging means comprising an oscillator including a tube having a grid and a plate, an oscillating circuit connected between the plate and grid and operating on the slope of its resonance curve, and a grid resistor; modulating means connected with the grid resistor, a second oscillator generating a carrier frequency connected with the modulating means, amplifying means connected with the modulating means including at least one amplifying tube have a grid and a bias resistor connected with the tube biasing the grid beyond cut off to a point to retain not more than ten percent of the signal, and demodulating means connected with the amplifying means.

25. A gage as in claim 24 including capacitive adjusting means connected with one of the gaging means including a plurality of circumferentially spaced conducting members and a conducting member rotatable and connected with the scanning gaging means, amplifying means connected with demodulating means, and a cathode ray tube having vertical beam deflecting means connected with the next aforesaid amplifying means.

26. A gage as in claim 24 including horizontal beam deflecting means for the cathode ray tube, and a sweep circuit connected with the horizontal beam deflecting means including rotatable condenser driven by the scanning gaging means.

27. Apparatus for measuring the thickness of a coating applied to a moving strip comprising a first means adjacent said strip for obtaining an electrical impulse proportional to the thickness of the uncoated strip, a second means remote from the first means adjacent said strip for obtaining an electrical impulse proportional to the thickness of the coated strip, means for subtracting said first impulse from said second impulse to obtain a net impulse proportional to the coating thickness and for indicating the net impulse, and means for delaying the impression of said first impulse to said last named means until that portion of the uncoated strip originally gaged reaches said second means.

28. Apparatus for measuring the thickness of a coating applied to a moving strip comprising a first means adjacent said strip for obtaining an electrical impulse proportional to the thickness of the uncoated strip, a second means remote from the first means adjacent said strip for obtaining an electrical impulse proportional to the thickness of the coated strip, an indicator having means for subtracting said first impulse from said second impulse to obtain a net impulse proportional to the coating thickness, said subtracting means controlling the indicator to indicate the net impulse, and means for delaying the impression of said first impulse to said last named means until that portion of the uncoated strip originally gaged reaches said second means.

29. Apparatus for measuring the thickness of a coating applied to a moving strip comprising a first means adjacent said uncoated strip for obtaining a first electrical impulse proportional to the thickness of the uncoated strip, recording means responsive to the electrical impulse to record the proportional thickness of the uncoated strip, means responsive to the record to regenerate the electrical impulse at a delayed time interval corresponding to the time elapsed for the sheet to reach a second impulse means, a second means remote from the first means adjacent said coated strip for obtaining a second electrical impulse proportional to the thickness of the coated strip, and an indicator having means to which the regenerated first impulse is applied for subtracting said regenerated first impulse from said second impulse to obtain a net impulse proportional to the coating thickness, said indicator being controlled by the net impulse.

30. Apparatus for measuring the thickness of a coating applied to a moving strip comprising a first means adjacent said uncoated strip for obtaining a first electrical impulse proportional to the thickness of the uncoated strip, magnetic recording means responsive to the electrical impulse to record the proportional thickness of the uncoated strip, means responsive to the recording means to regenerate an electrical impulse at a delayed time interval corresponding to the time elapsed for the sheet to reach a second impulse means, a second means remote from the first means adjacent said coated strip for obtaining a second electrical impulse proportional to the thickness of the coated strip, and an indicator having means to which the regenerated first impulse is applied and having means to which the second impulse is applied for subtracting said first impulse from said second impulse to obtain a net impulse proportional to the coating thickness, said indicator being controlled by the net impulse.

31. Apparatus for measuring the thickness of a coating applied to a moving strip comprising a first means adjacent said strip for obtaining an electrical impulse across the width of the sheet proportional to the thickness of the uncoated strip, a second means remote from the first means adjacent said strip for obtaining an electrical impulse across the width of the sheet proportional to the thickness of the coated strip, means for subtracting said first impulse from said second impulse to obtain a net impulse proportional to the coating thickness and for indicating the net impulse, and means for delaying the impression of said first impulse to said last named means until that portion of the uncoated strip originally gaged reaches said second means.

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