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APPARATUS FOR DETECTION OF FLAWS
BY MEANS OF MICROWAVES
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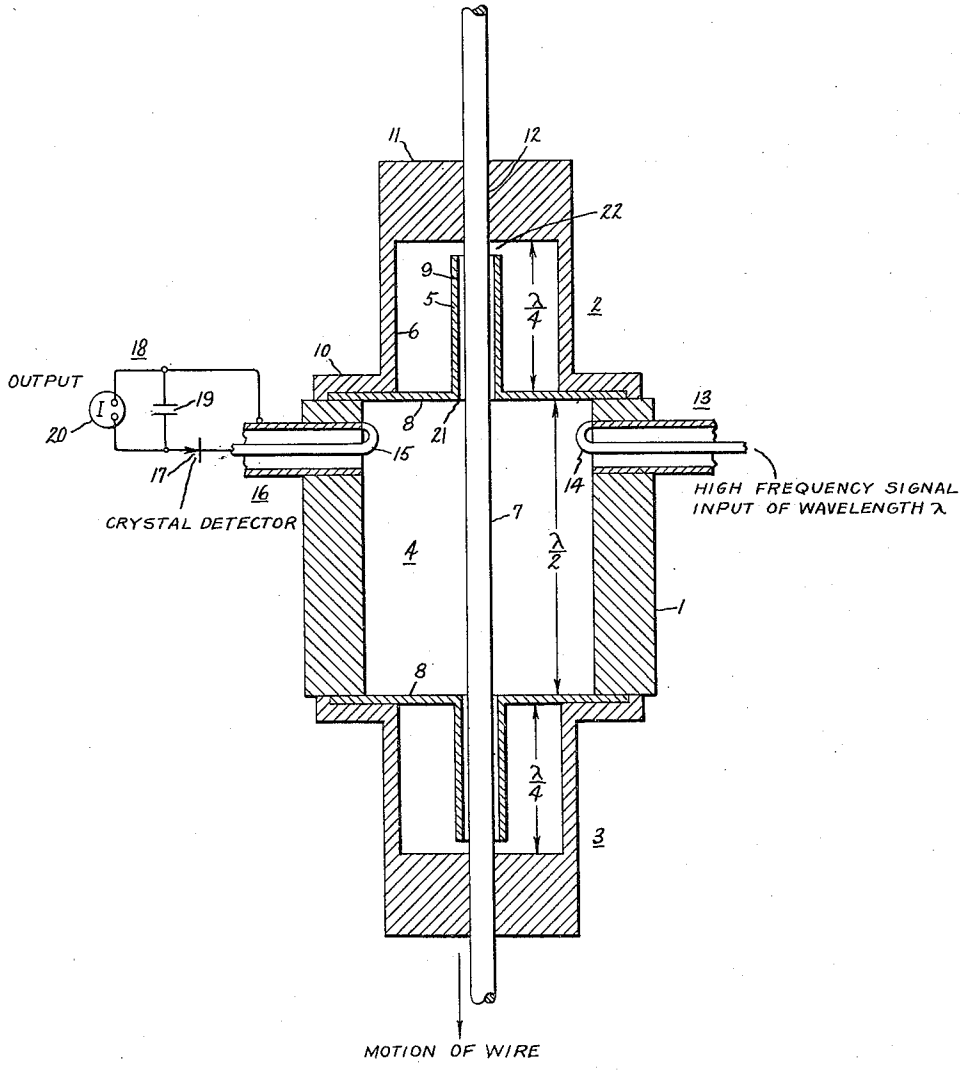

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APPARATUS FOR DETECTION OF FLAWS BY MEANS OF MICROWAVES

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The present invention relates in general to apparatus for the detection of flaws in conductors by means of electromagnetic waves and in particular relates to improvements in apparatus for the detection of flaws in wire-like conductors by means of microwaves.

The invention may be used to detect occluded scale and surface imperfections, such as cuts and nicks, in aluminum wire, for instance.

Accordingly, it is a general object of my invention to provide means for the detection of flaws in conductors by means of electromagnetic waves.

It is a further object of my invention to provide a microwave flaw detector for the detection of flaws in conductors such as wire and the like.

The features of the invention desired to be protected are pointed out in the appended claims. The invention itself together with its further objects and advantages may best be understood by reference to the following description and to the single figure of the drawing which represents a cross-sectional view of the apparatus for carrying out my invention.

The invention is carried out in the embodiment shown in the drawing by means of a cavity resonator of which the wire-like conductor under test forms a part. The wire-like conductor is inserted into the cavity resonator through wall members which form high frequency chokes with the wire-like conductor. The high frequency choke arrangement permits insertion of the conductor while at the same time prevents the escape of high frequency energy from the resonator. Means are provided for coupling signals into the resonator and for detecting and indicating the signal level in the resonator. As the wire-like conductor is inserted or drawn through the resonator, an imperfection, such as occluded matter or cuts, causes a drop in the signal level in the resonator due to increased resistive losses introduced into the resonator or due to the detuning of the resonator caused by the cuts. Since the inner and outer conductors of the choke forming members are much closer together than in a normal resonator or transmission line, slight changes in cross section in the wire-like conductor which comprises part of the inner conductor of the choke cause a considerable detuning of the choke and consequently of the cavity with a corresponding drop in signal level of the resonator.

Referring now with particularity to the single figure of the drawing, there is shown a generally cylindrical conductive hollow member 1 closed in with conductive end portions 2 and 3 to form a cavity resonator 4. Copper or brass or any similar material of good conductivity may be used in the construction of the resonator.

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End portion 2 comprises two members 5 and 6 together forming an end wall 2 with an opening for the insertion of a wire-like conductor 7 within the hollow member 1 and at the same time providing a high frequency choke means by means of which high frequency energy is prevented from escaping from the cavity resonator 4. The inner member 5 of end wall 2 comprises a cylindrically shaped conductor having a flanged portion 8 located at one end. The inner surface 9 of the cylindrical member 5 forms part of the outer conductor of the choke; the wire-like conductor 7 forms part of the inner conductor of the choke. The outer member 6 of the end wall 2 fits over the corresponding inner member 5 to form the re-entrant portion of the above referred to choke. The outer member 6 comprises a hollow cylindrical portion at one end of which is located a flange 10 by means of which attachment is made to the flange portion 8 of the inner member 5. At the other end of the outer member is located an end wall 11 with a hole 12 adapted to pass the wire-like conductor 7. The inner and outer members 5 and 6 are suitably fastened together and to the cylindrical member 1 at their respective flanged portions 8 and 10 as shown by soldering or clamping or by both soldering and clamping to form the end wall 2 of resonator 4. The end wall 3 member is identical to end wall member 2. The hollow member 1 with the end walls 2 and 3 and the wire-like conductor 7 forms a cavity resonator 4 of the concentric line type. It should be noted that the characteristic impedance of the section of transmission line formed by the inner surface of 5 and the wire-like conductor is considerably smaller than the characteristic impedance of the section of transmission line forming the cavity resonator section proper since ratio of the inductance per unit length to the capacity per unit length of transmission line is smaller. Because of the closeness of the inner and outer conductors in the choke portion of the apparatus, a small nick or cut in the wire-like conductor 7 will produce a large percentage change in the spacing between inner and outer sections at that point to cause an appreciable discontinuity in the section of transmission line forming the choke and consequently detuning it. The detuning will be reflected in the resonator section and will be indicated as a change in the output level of the signal.

Means are provided for coupling a high frequency signal into the cavity resonator 4 and in the embodiment shown takes the form of a concentric transmission line 13 connected to a source of high frequency signal, the other end of which is connected to the cavity resonator 4 and is terminated in a loop 14. It will be apparent to

those skilled in the art that other means of coupling energy into the cavity resonator may be utilized. Energy is coupled from the resonator by means of a similar loop 15 which is connected to a transmission line 16. It is apparent that other means of coupling energy from the resonator may readily be utilized. The signal is detected by means of a rectifier 17 which may be a crystal detector and appropriate detection circuits 18. In the embodiment shown, the one end of the crystal detector 17 is connected to the center conductor of the transmission line 16 and the other end is connected to the outer conductor of the transmission line 16 through a by-pass capacitor 19. The signal level within the cavity resonator 4 is measured by microammeter 20. It is apparent to those skilled in the art that other means may be used to detect changes in the signal level within the cavity.

The apparatus may be used for the detection of nonresistive as well as resistive flaws. Resistive flaws take the form of occluded scale in the wire. Nonresistive flaws take the form of nicks or cuts in the wire. The apparatus may be operated at any suitable frequency at which the effects to be hereinafter described take place. It has been found that 3,000 megacycles is quite satisfactory for practical purposes. It should be observed that the resonator 4 is one-half a wavelength long at the frequency of operation of the apparatus. The resonator 4 is suitably excited by a microwave signal. With a section of wire 7 free from defects in place as shown in the figure, the frequency of the high frequency input signal is adjusted to give maximum rectified output at microammeter 20. If the wire 7 is moved axially through the cavity, a defect in the surface will cause a drop in the detector output as it passes through the re-entrant choke. For slow passage of wire, this drop in output can be used as a visual indication of the flaw. For rapid passage of the wire, the change in output can be used to trigger a relay after being suitably amplified. In order to facilitate amplification, the high frequency input can be amplitude modulated at an audio rate.

The principle of operation is as follows: At resonance, a large current flows radially in the end plates 6 of the cavity resonator 4. This current must flow into the outer conductor of the re-entrant choke at point 21 and return by way of the wire 7. This large current is thus forced to flow across the surface imperfection. Two effects are possible. If the surface imperfection consists of occluded scale or other foreign substance, of a higher resistivity than the wire, the surface resistivity will be increased. Since the depth of current flow is very slight because of the use of high frequency excitation, this will cause an appreciable change in the losses in the re-entrant choke, which are a maximum at the high current point near 21. With proper design, the change in losses is a large enough proportion of the total losses so that the change shows up as a transmission loss between input and output couplings 13 and 16, respectively. If, on the other hand, the surface imperfection is a nick in the otherwise smooth and pure material of the wire, the discontinuity in the characteristic impedance as the wire passes through the choke will detune the cavity resonator 4, also resulting in a change in detector output. Both effects may be present for a given imperfection.

The re-entrant chokes are made approximately one-quarter wavelength long as shown in the figure so that at point 22 the current flowing across the joint between wire and choke is a minimum. In this way, changes in contact resistance due to passage of the wire through the guide hole 12 have no effect on the output.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention and its broad aspects. I therefore aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Detector apparatus for detecting flaws in wire-like conductors comprising a cavity resonator having walls of high current flow, choke means located in two of said walls permitting the passage of said wire-like conductor through said cavity resonator, said choke means comprising with said wire-like conductor a section of short circuited transmission lines having a high current flow region adjacent said walls, means supplying high frequency signals to said cavity resonator, detecting means for detecting changes in the signal level due to imperfections in said wire-like conductor.

2. Detection apparatus for the detection of flaws in wire-like conductors by means of electromagnetic waves comprising a cylindrically shaped cavity resonator having an axial length of a multiple of a half wavelength at the frequency of said waves, choke means in the end walls of said resonator permitting the passage of said wire-like conductor through said cavity, said choke means comprising with said wire-like conductor a section of short circuited transmission line having a high current flow region adjacent said wall, means supplying high frequency signals to said cavity resonator, detecting means for detecting changes in the signal level due to changes in the surfaces of said wire-like conductor.

3. Detection apparatus for the detection of flaws in wire-like conductors by means of high frequency currents comprising a hollow conductive member having end walls of high current flow, opening means in each of said end walls for the insertion of said wire-like conductors in said hollow member, said hollow member with said wire-like conductors forming a concentric line cavity resonator, said opening means with said wire-like member forming a concentric line choke so that high current flow over said wire in region where said wire enters and leaves said hollow member, the characteristic impedance of said choke member being considerably smaller than characteristic impedance of said resonator.

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