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SPIN RESONANT TRANSDUCER

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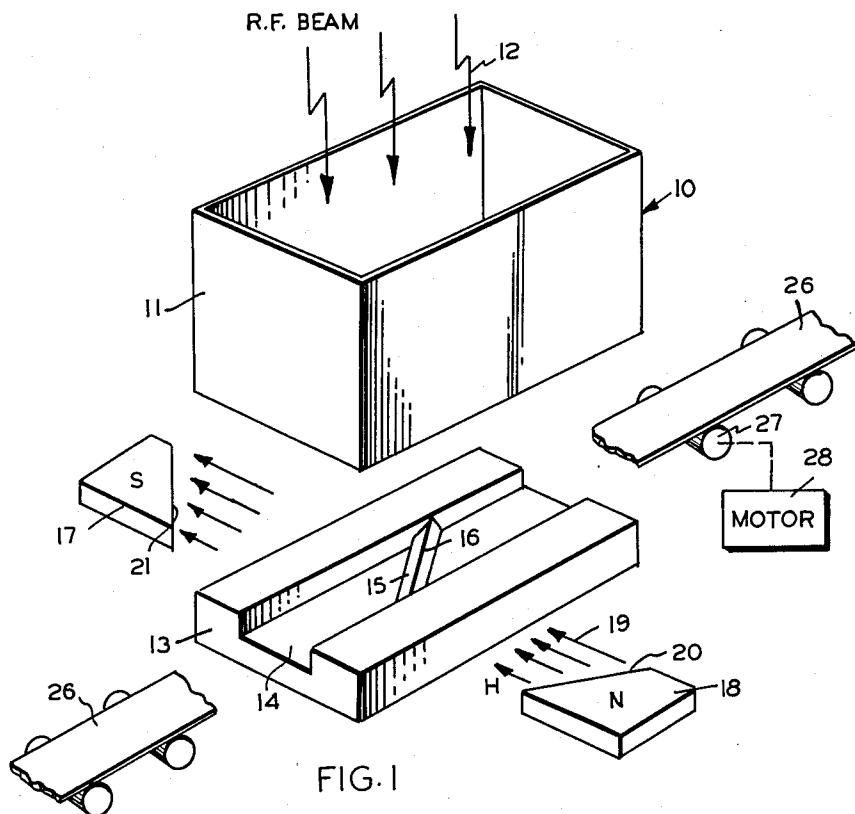


FIG. 1

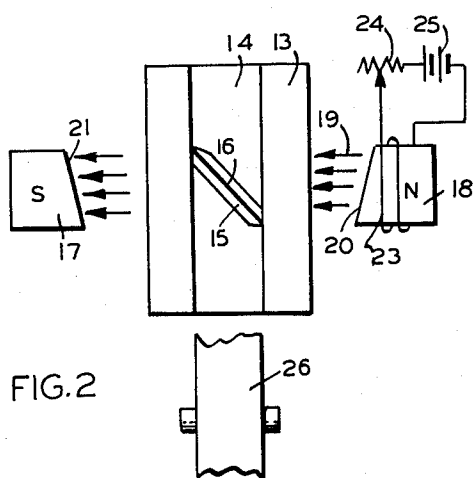


FIG. 2

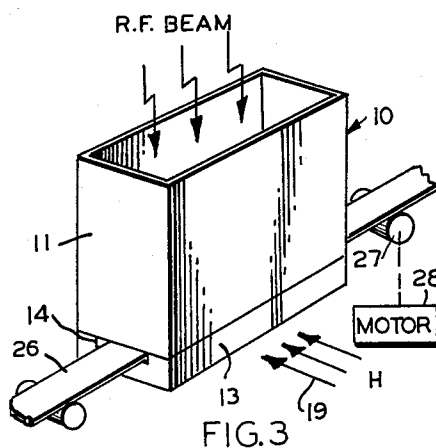


FIG. 3

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SPIN RESONANT TRANSDUCER

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5 Claims. (Cl. 340—173)

This invention relates to improvements in microwave frequency transducers, and more particularly to microwave cavity transducers for converting time variable radio beams into frequency spectrum images for such purposes as recording or storage of information.

In copending applications of Kenneth E. Peltzer, Serial No. 102,429, filed April 12, 1961 and Francis Ryder, Serial No. 292,405, filed July 2, 1963 of the same assignee, there is disclosed frequency sensitive transducers for microwave radio beams that resolve the Fourier component frequencies of the beam into frequency spectrum images in the form of heat patterns for recording on a heat sensitive tape. These transducers employ spin resonant materials that are tuned into frequency resonance with the microwave radio beam by means of high intensity static magnetic fields being produced by external magnets or electromagnets.

In the construction of such transducers, it is generally necessary to employ rather large and heavy magnets to produce the high intensity magnetic fields required, and accordingly it is a primary object of the present invention to provide a transducer construction for these purposes in which the size and weight of the magnets may be materially reduced.

Very generally according to the present invention, this desired result is obtained by constructing the transducer in such manner that the poles of the energizing magnet may be placed much more closely together, in order to reduce the air gap between these poles. Shortening of this air gap materially reduces the reluctance of the magnetic circuit and enables the use of much smaller and lighter magnets for producing the same intensity of magnetic flux being required by the transducer. Alternatively, reducing the reluctance of the magnetic circuit by shortening the air gap, permits a much larger magnetic flux to be produced by the same magnets thereby permitting the range of usefulness of the transducer to be extended.

Other objects and additional advantages of the present invention will be more readily appreciated by those skilled in the art after a detailed consideration of the following specification taken with the accompanying drawings wherein:

FIG. 1 is a perspective view, partly cut away, and illustrating one preferred resonant cavity type transducer according to the present invention,

FIG. 2 is a plan view looking down at the base of the cavity and illustrating the spatial relationship of the static magnetic field and the spin resonant material, and

FIG. 3 is a perspective view illustrating the assembled resonant cavity transducer, and schematically illustrating the motor drive and guide means for the recording tape.

Referring to the drawings for a detailed consideration of one preferred embodiment of the invention, the recording transducer is generally comprised of a microwave resonant cavity 10 having a rectangularly shaped waveguide portion 11 being open at one end to receive an electromagnetic beam 12 at microwave frequencies, together with a solid rectangular base member 13 of electrically conducting material and having surface dimensions that are coextensive with the end opening of the waveguide 11 and suitably fastened to the end of the waveguide to form a resonant cavity therewith.

The base member 13 is provided with a centrally disposed groove or channel 14 within which is accommo-

dated an elongated bar shaped member 15 containing a spin resonant material. The bar 15 is generally triangularly shaped in cross section to provide a recording edge line 16 along its upper surface, and the bar 15 is considerably longer than the width of the channel 14 and is disposed diagonally across the channel and may occupy a considerable portion of the length of the base member 13.

Externally of the resonant cavity 10 is provided a pair of magnet poles 17 and 18 having elongated pole faces which are suitably supported and arranged in alignment with the bar of spin resonant material 15, to direct a static magnetic flux 19 at an angle through the cross sectional bar 15 and along its complete length, as is best shown in FIG. 2. For frequency spectrum recording, each position along the length of the bar 15 is energized by a magnetic field of different intensity; and to provide this different intensity of the magnetic flux 19 at each position, the pole faces 20 and 21 of the magnet poles 18 and 17, respectively, are uniformly inclined away from each other to progressively increase the air gap between the poles in a direction along the length of the bar 15. By this construction, the air gap between the poles is progressively increased to produce a progressively reduced flux along the length of the bar 15 thereby energizing each different position along the length with a different intensity magnetic field.

The spin resonant material employed in the bar 15 is of a class of materials characterized by being frequency sensitive to signals in the microwave range of frequencies to absorb energy from the signals, and being frequency tunable by the static magnetic field to respond to or resonate at different frequencies in the microwave band according to the Lamour frequency formula. Consequently, according to this formula, the spin resonant material is tuned to a resonance at a frequency in proportion to the amplitude of the externally applied static magnetic field 19, and consequently with the arrangement illustrated each position along the bar of material 15 is tuned to resonate at a different frequency.

In operation, the electromagnetic beam 12 is applied at the inlet of the resonant cavity 10 and is therefore directed to illuminate the complete bar 15. The static magnetic field 19 produced by magnets 17 and 18 is adjusted by such means as varying the amplitude of current through the electromagnetic winding 23 (FIG. 2) to tune the spin resonant bar 15 to the bandwidth of frequencies of the beam 12. Since each position along the bar 15 is tuned to a different frequency in this bandwidth, each of the different component frequencies of the beam 12 is absorbed at a different position along the length of the bar to provide a frequency spectrum image of the beam. The frequency components being absorbed in the spin resonant material are reradiated in the form of heat, and consequently a heat pattern representing the spectral frequency components of the beam 12 is produced in the bar 15.

For recording these heat images, a tape 26 carrying heat responsive material therein or thereon is introduced into the cavity 10 through the groove or channel 14 in the base block 13, and in being guided through the groove 14, passes over the sharp recording edge 16 of the bar 15 of spin resonant material. The heat patterns being produced in the bar 15 are therefore transferred to the tape to record the heat images on the tape.

It will be noted that the diagonally oriented position of the bar 15 in the groove 14 permits the magnet poles 17 and 18 to be placed on opposite sides of the cavity 10 and spaced apart by the narrow wall of the cavity, while still providing the desired variable intensity distribution of the static magnetic field along the length of the bar 15. If on the other hand, the bar 15 were positioned transversely across the channel 14, rather than diagonally as shown, the magnet poles 17 and 18 would be required to

be rotated by 90° and placed adjacent the narrow walls of the waveguide (not shown) in order to provide a varying flux along the length of the bar 15, as desired. In the design of a typical rectangular waveguide, such as a waveguide for propagating the TM₁₁ mode, the broad walls of the waveguide are considerably longer than the narrow walls, and therefore in the event that the bar 15 were positioned transversely across the groove 14, the magnetic poles would be required to be separated by a much larger air gap than in the arrangement according to the present invention. In this case, a considerably larger and heavier external magnet construction would be required to provide the necessary flux intensity 19 for tuning the bar 15 than is required by the preferred construction of the present invention. Thus according to the present invention, the angular orientation of the bar 15 with respect to the static magnetic field 19 permits a considerable reduction in the size and weight of the magnets or alternatively provides a much greater flux intensity for magnets of the same size and weight.

As is disclosed in much greater detail in the copending applications above referred to, a number of different spin resonant materials may be employed in practicing the invention, such as various paramagnetic materials, free radical materials, irradiated crystals, and others. One free radical material which has been found to be particularly useful is Diphenylpicrylhydrazyl, which is a free radical that is stable at ambient temperatures and obtainable on the open commercial market in solid particle form. Consequently, using this preferred material, DPPH, the bar or layer 15 in solid form may be easily formed in the shape desired. On the other hand, if it is desired to employ a spin resonant material of a liquid or gaseous form, the fluid spin resonant material may be enclosed within a microwave transparent container (not shown) in the shape of the bar 15 and having walls of heat transferring material, thereby enabling the transfer of the heat image to the recording tape 26. Thus, it is believed evident that the present invention is not limited to the use of any particular spin resonant materials.

With respect to the heat sensitive recording tape 26, this tape may be formed of a suitable base tape of Mylar or the like, having a coating of heat sensitive or thermographic material thereon. A large number of such heat sensitive materials are available on the open commercial market and variably known as thermographic copy papers or sheets. One preparation producing a fairly good quality color change, and turning black when exposed to elevated temperatures is comprised of 30% of urea; 10% of nickel acetate; 3% of thiourea and the remainder of water. This composition is applied in liquid form onto the suitable base of plastic tape by flow coating or other process, and is dried to produce the usable heat sensitive tape or record. A large number of other heat sensitive materials are also readily available that produce change of color with heat or otherwise vary their chemical or physical properties in a detectable manner when they are heated. Accordingly, this invention is not to be considered as being limited to any specific heat sensitive material.

In many of these heat sensitive materials, the critical temperature required to effect a change in color or other desired change in the tape may be greater than that which is produced by the heat pattern in the resonant mass 15. In such instances, the tape 26 may be preheated (not shown) before being introduced into the transducer 10, to a temperature just below the critical temperature or range necessary to effect color change. Upon the added application to the tape 26 of the heat pattern by the spin resonant mass 15, the temperature of the tape at the discrete locations of the heat image is therefore sufficiently raised to exceed this critical temperature thereby producing the recording of the heat pattern.

In the preferred embodiment, it is noted that the magnets 17 and 18 for producing the tuning magnetic field

are located outside of the resonant cavity 10. For this reason, it is preferred that the waveguide section 11 and the base member 14 be constructed of an electrically conducting material but one that is nonmagnetic. One example of suitable materials, are waveguides formed of aluminum and a baseblock formed of aluminum or brass.

In the preferred construction, it is also noted that the tape is introduced into the resonant cavity and therefore is exposed to the electromagnetic beam at microwave frequencies. Normally the tape will be formed of nonconducting materials such as suitable plastics as described above or the like, and consequently in the event that the tape is exposed to the electric vector of the beam, microwave heating of the tape results that tends to obscure any image of heat being produced in the spin resonant material 15. To eliminate or greatly minimize any such spurious heating of the tape by the beam 12, the spin resonant bar 15 is disposed directly or closely adjacent to the base 13 of electrically conducting material, which forms a short circuiting end wall for the microwave cavity. At this short circuiting end wall, the electric field vector of the beam 12 is at a minimum amplitude whereas the magnetic field vector is at a maximum. In the recording process the magnetic field vector of the beam 12 transfers energy to the spin resonant material. Consequently, by providing the spin resonant material 15 in a region of maximum magnetic field of the beam 12, an optimum energy coupling is obtained to the spin resonant material; whereas at the same time, neither the spin resonant material 15 nor the tape 26 is exposed to the electric field vector of the beam to produce spurious heating.

As is disclosed in the above copending application of Francis Ryder, the spin resonant material and the tape may also be located at other positions with the resonant cavity where the electrical vector of the beam 12 is at a node or minimum amplitude.

Although but one preferred embodiment of the invention has been illustrated and described, it is believed evident to those skilled in the art that many changes may be made without departing from the spirit and scope of this invention. For example, although the resonant cavity is disclosed as being formed of a rectangular shaped waveguide 11 and base member 13, it is evident that otherwise shaped microwave cavities may be provided in circular cross section configuration or other known configurations capable of supporting a microwave radio beam 12 in other modes. It is also believed evident that although the spin resonant material 15 is disclosed as being in the form of a bar having a triangular cross section with a sharp recording edge 16, other cross sectional configurations of the bar may be made with the same result. Furthermore, the bar 15 need not necessarily be linearly shaped, but may be curved along its length or otherwise formed as desired for the application intended. Still other changes may be made in the manner of transferring the heat images to a recording tape, which may be in the form of individual heat sensitive cards which are successively fed into the transducer or other type recording medium. Similarly, although the magnets 17 and 18 are disclosed as producing a uniformly nonhomogeneous static magnetic field, by providing progressively separated pole faces, it is believed evident that otherwise shaped magnetic poles may be supplied to provide nonhomogeneous magnetic fields of different configurations for purposes of recording frequency codes and other types of intelligence.

Since these and many other changes may be made by those skilled in the art without departing from the spirit and scope of this invention, this invention is to be considered as being limited only by the following claims appended hereto.

What is claimed is:

1. A radio frequency transducer for electrical waves in the microwave region comprising: a microwave resonant

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cavity having means to receive the radio wave, said cavity comprising a rectangularly shaped waveguide section having broad and narrow walls, and a base member closing one end of the guide, said base member having a central groove along its length to define a guideway for a recording tape being directed through the cavity, a stylus containing a spin resonant material being disposed in the groove at an acute angle the length of the groove, magnet means external of the cavity and directing a magnetic flux into the cavity to illuminate the stylus, said magnet means producing a nonhomogeneous magnetic field to energize different positions along the length of the stylus with a different intensity magnetic field.

2. A radio frequency transducer for recording signals at microwave frequencies comprising: a cavity for receiving an intelligence carrying electromagnetic wave, spin resonant material supported within the cavity at a position where the electric field vector of the wave is minimized and the magnetic field vector of the wave is maximized, magnetic field producing means for directing a magnetic flux to energize the spin resonant material along its length, said spin resonant material being oriented at an acute angle with respect to the lines of flux produced by the magnet, and means for introducing a heat sensitive recording tape into the cavity in heat transferring relationship with the spin resonant material.

3. A radio frequency transducer for radiant waves in the microwave radio frequency band comprising: a member having a cavity that is tuned in the microwave and including means for directing the radiant wave to be transduced into the cavity, a frequency sensitive spin resonant material disposed within the cavity at a position where the electric field of the wave is at a minimum and the magnetic field of the wave is at a maximum, said cavity being provided with openings for receiving an elongated recording medium in image transferring relationship with the spin resonant material, said spin resonant material and opening in the cavity being arranged in such manner that the longitudinal axis of the medium and

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the axis of the material are transverse and at an acute angle to one another, and magnetic means for energizing different positions along said axis of the spin resonant material with different intensity magnetic fields.

4. A recording transducer for microwave frequency signals comprising: a waveguide for receiving the signal, a termination for the waveguide to provide a cavity therein, a spin resonant material disposed within the waveguide at a position where a minimum electric vector of the signal exists, means associated with the waveguide for enabling a recording medium to be introduced into the guide and in image transferring relationship with the material, magnetic means external of the waveguide for directing a nonuniform low frequency magnetic field to energize the spin resonant material with different intensities energizing different positions along its length, said magnetic means being oriented at a transversely acute angle with respect to the spin resonant material to minimize the air gap traversed by the low frequency magnetic field.

5. A radio frequency recording transducer comprising: a waveguide having broad and narrow walls, magnetic means located proximate said broad walls to direct a low frequency magnetic field through a portion of the interior of the waveguide, means for introducing a radio frequency wave into the waveguide having a magnetic vector component transverse to the low frequency magnetic field, an elongated spin resonant material supported within the waveguide and illuminated by the wave at a position when a minimum electric vector of the wave exists, said material being oriented in a direction transverse to low frequency magnetic field and at an acute angle with respect thereto, and means for introducing a recording medium into the waveguide and in heat transferring relationship to the spin resonant material, said recording medium being introduced transversely to said material and at an acute angle with respect thereto.

No references cited.