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C. L. VICE

2,980,988

METHOD OF FABRICATING TUBES

Filed Jan. 5, 1959

Fig. 1

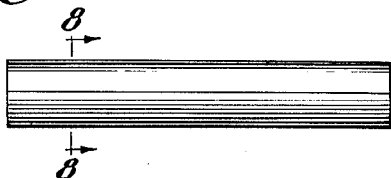


Fig. 2

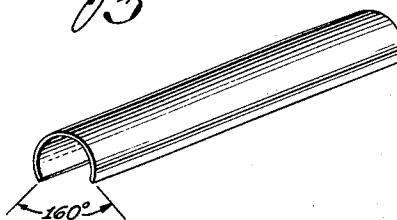


Fig. 3



Fig. 4

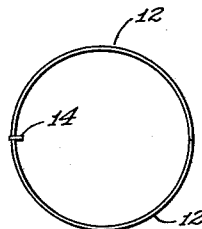


Fig. 5

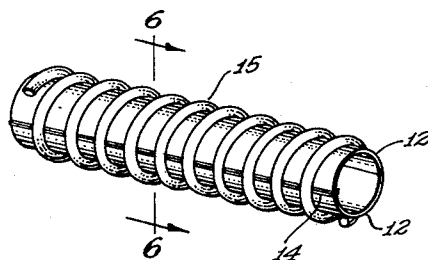


Fig. 6

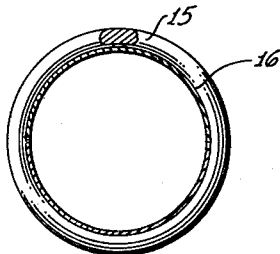


Fig. 7

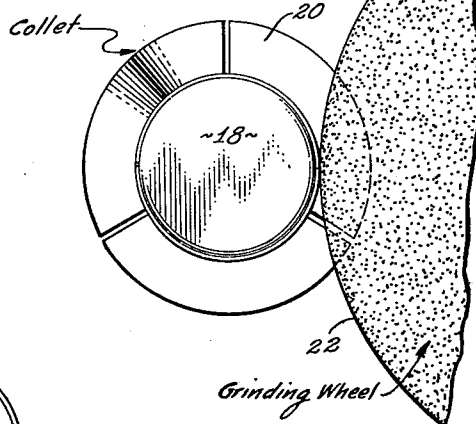
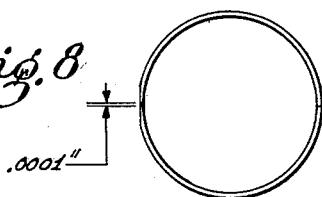


Fig. 8



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1

2,980,988

METHOD OF FABRICATING TUBES

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7 Claims. (Cl. 29—155.59)

This invention is directed to the problem of fabricating a tubular body with exceedingly high precision. While the invention is widely applicable for its basic purpose, it has been initially applied to the production of a specialized transducer tube for magnetically recording and reproducing signals. This initial practice of the invention has been selected for the present disclosure and will provide adequate guidance for those skilled in the art who may have occasion to apply the same underlying principles to other specific fabrication purposes.

The problem in this particular practice of the invention is to fabricate accurately a transducer tube of magnetic material for positioning transversely of a traveling magnetic tape. Such a transducer tube has a longitudinal gap adjacent the traveling tape and is maintained either under longitudinal tension or under longitudinal compression so that successive relaxation waves may be sent lengthwise of the tube to form successive traveling zones at which the transducer records signals on the traveling tape or reproduces previously recorded signals. The transducer tube as used in this manner has special utility for recording and reproducing television signals. It will be readily appreciated that such a transducer tube must be fabricated with a high degree of precision since exceedingly minute variations in the cross-sectional dimension along the length of the tube and especially variations in the width of the longitudinal gap will cause corresponding distortion of the signals.

The required degree of accuracy and uniformity cannot be achieved by simply cutting a longitudinal gap in a piece of tubing stock. One reason is that tubing stock is not accurately dimensioned. Another reason is that strains are inevitably created by clamping tubing for such a cutting operation and further strains are created by the cutting operation itself. A third reason is that it is hardly possible to cut a longitudinal gap of exceedingly small width on the order of .0001 inch, and especially so since smooth even edge faces are mandatory. These problems relating to the use of tube stock are complicated by the requirement that the transducer tube be magnetically annealed to achieve optimum domain orientation. Such annealing inevitably creates some degree of distortion and it is extremely difficult to restore a distorted tubular configuration.

The invention solves these problems by fabricating accurate half cylinders of suitable magnetic material and then bonding the half cylinders together with a spacer strip of non-magnetic material between one pair of the confronting longitudinal edges to form the desired longitudinal gap. It has been found that the half cylinders may be magnetically annealed and then straightened within relatively small tolerances, and that these tolerances may be accommodated by starting with half cylinder blanks substantially thicker than the wall of the finished transducer tube. The curved blanks are of smaller inside radius of curvature and larger outside radius of curvature than the desired transducer tube and the excess material

2

is subsequently removed from inside and outside the assembly after the bonding step.

The concept of first processing half cylinders simplifies the task of providing accurately straight planar edge faces at the gap since the edges that are to form the gap are fully exposed and accessible for the necessary processing. In this regard, a feature of the invention is the further concept of making the half cylinder blanks over-size in circumferential dimension, i.e., of greater circumferential extent than 180° and subsequently lapping the two longitudinal edges to reduce the circumferential dimension to 180° with consequent forming of edge faces that accurately conform to longitudinal diametrical planes. This procedure not only provides the desired straight smooth planar edge faces of the gap in the finished transducer tube, but also accurately dimensions the half cylinders for matching together to form the transducer tube.

The two half cylinders and the accurately dimensioned non-magnetic spacer strip are accurately assembled to form a composite cylinder and then are held together under transverse compression for the duration of the bonding step that converts the assembly into a unified cylinder. For this purpose, the assembly may be tightly embraced by suitable metal means and then the embraced assembly may be dip brazed or furnace brazed to achieve the desired unification. In this regard, a feature of the preferred practice of the invention is the concept of encircling the assembly with metal means having a smaller co-efficient of thermal expansion than the assembly. Such an encircling means expands less than the assembly in response to the rise in temperature for the brazing operation and consequently forces the assembly parts together under high pressure.

An outstanding advantage of this procedure is that pressing the two planar edge faces of the two half cylinders against the opposite sides of the accurately dimensioned spacer strip for the brazing operation results in uniform spacing of the two edge faces with high precision in the final unified assembly. After the brazing operation, the unified cylinder is lapped inside and out to the desired final inside and outside diameters and then the exterior of the tube is lapped along the region of the longitudinal spacer strip to form a uniform gap face.

The invention may be fully understood from the following detailed description together with the accompanying sheet of drawing.

In the drawing, which is to be regarded as merely illustrative:

Fig. 1 is a side elevation of a finished transducer tube that has been produced in the manner taught by the invention;

Fig. 2 is a perspective view showing the configuration to which the uniform sheet material is rolled to produce a curved blank for a half cylinder;

Fig. 3 shows diagrammatically the manner in which a half cylinder blank is lapped along its longitudinal edges to reduce its circumferential extent from 200° to 180°;

Fig. 4 is an end elevation showing how the two half cylinders are assembled with an intervening spacer strip;

Fig. 5 is a perspective view showing how a constricting coil spring may be used to hold the assembly together under transverse compression for the duration of the bonding step;

Fig. 6 is a transverse section taken as indicated by the line 6—6 of Fig. 5 showing the brazed assembly or unified tube mounted on a mandrel for the purpose of a grinding operation;

Fig. 7 is an end elevation of the mounted assembly on the mandrel at an advanced stage in the operation of grinding material away from the outer surface of the unified tube; and

3

Fig. 8 is an enlarged section of the finished transducer tube taken as indicated by the line 8—8 of Fig. 1.

The desired finished transducer tube is shown in side elevation in Fig. 1 and an enlarged end view is shown in Fig. 8. In this particular embodiment of the invention, the transducer tube is an accurately formed tube of uniform diameter three inches long with a wall thickness of .006 inch, the inside diameter of the tube being .154 inch and the outside diameter being .166 inch. As indicated in Fig. 8, the uniform width of the longitudinal gap is .0001 inch.

Fig. 1 shows how a strip of sheet stock of magnetic material may be rolled to cylindrical curvature for the purpose of producing a curved blank for one of the two half cylinders. In this instance, the material used is an alloy known to the trade as Alfenol. As indicated in Fig. 2, the circumferential gap between the longitudinal edges of the rolled strip is approximately 160°, the circumferential dimension of the blank being approximately 200°. Thus the segment of a cylinder shown in Fig. 2 is substantially over-sized in circumferential extent in comparison to the desired 180° circumferential extent of a true half cylinder.

As heretofore stated, the thickness of the sheet material for starting the fabrication procedure is substantially greater than the desired final thickness. In this instance, the thickness of the starting metal sheet is .014 inch. The sheet of excessive thickness is rolled to an inside diameter smaller than the desired finished inside diameter to permit the removal of material from the inner surface and is rolled to an outside diameter that is greater than the desired finished outside diameter to permit the removal of material from the outer surface. In this instance, the starting inside diameter of the formed sheet metal blank in Fig. 2 is .145 inch and the outside diameter is .170 inch. These dimensions permit the subsequent removal of material from the inner surface to a depth of .004 inch and the removal of material from the exterior surface to a depth of .004 inch.

While the half cylinder blanks are preferably produced in the manner described to this point, it is to be understood that the blanks may be provided by other procedures. For example, the half cylinder blanks may be cut from tube stock if tube stock of the required dimensions is available.

Magnetic annealing of the half cylinder blank of Fig. 2 for optimum domain orientation is the next step, with the usual inevitable distortion of the rolled sheet. After the annealing step, the rolled sheet is straightened in any suitable manner to reduce the distortion to within the tolerances permitted by the over-size dimensions of the blank. This step presents no special difficulties because the metal is not circumferentially continuous and because the inner surface of the metal is readily accessible. The straightening step may be carried out with the aid of various devices, for example by using a suitable mandrel.

The next step is to lap the half cylinder blank to reduce the circumferential extent to 180° and to produce longitudinal edge faces in the diametrical plane indicated by the broken line 10 in Fig. 3. This plane is the plane of the lapping surface when the edge material is finally removed to reduce the circumferential extent precisely to 180°.

Fig. 4 shows how two half cylinders 12 may be assembled with an intervening spacer strip 14 of non-magnetic material to form a composite cylinder with the desired longitudinal gap in the magnetic material. The spacer strip is accurately dimensioned with a uniform thickness of .0001 inch, the width being exaggerated in Fig. 4 for clarity of illustration. This assembly is then held together in some suitable manner for carrying out an appropriate bonding operation to unify the assembly. In this particular practice of the invention, the assembly shown in Fig. 4 is held together under transverse com-

4

pression by embracing the assembly with a constricting coil spring 15 in the manner shown in Fig. 5. The assembly, together with the constricting coil spring 15, is dip brazed by first applying the brazing metal to the assembly and then dipping the assembly in a tank of molten flux at a temperature of approximately 1550° F. in a well-known manner.

As heretofore indicated, a feature of the preferred practice of the invention is that the spring 15 is made of a metal having a lower co-efficient of thermal expansion than the material of the two half cylinders 12. Consequently, the spring expands less than the enclosed assembly in response to the rise in temperature for the brazing operation so that the constricting tension of the spring increases to hold the parts firmly together under high pressure during the brazing operation. It is to be understood that the same principle may be utilized in other ways, for example by using a series of metal rings having a relatively low co-efficient of thermal expansion.

After the brazing operation, the encircling coil spring 15 is removed and the unified cylinder is thoroughly cleaned to remove all of the adherent flux. The interior of the unified cylinder is then lapped to the desired final inside diameter of .154 inch. The semi-finished unified tube, which is designated 16 in Fig. 6, is then placed on a snug fitting mandrel 18 for removal of the excess peripheral material. Fig. 7 shows how the mandrel 18 may be placed in a collet 20 for the application of a grinding wheel 22 for this purpose. Finished grinding is used to achieve the final outside diameter.

The final step is to lap the exterior of the tube in the longitudinal region of the spacer strip 14 for the desired radial depth. In this instance, the thickness of the cylinder wall at the spacer strip 14 is reduced by lapping to .003 inch.

My description in specific detail of the presently preferred practice of the invention will suggest various changes, substitutions and other departures from my disclosure within the spirit and scope of the appended claims.

I claim:

1. A method of fabricating a uniform accurately shaped and dimensioned metal tube, including the steps of: providing two metal blanks for half cylinders, each of said blanks being of greater thickness than the desired thickness of the wall of the tube, each of said blanks being cylindrically curved with an inside radius of curvature less than the inside radius of curvature of the desired tube and an outside radius of curvature greater than the outside radius of curvature of the desired tube, each of said sections being of greater than 180° in circumferential extent; removing material from the longitudinal edges of said blanks to form edge faces in longitudinal diametrical planes and to reduce the circumferential extent of the blanks to substantially 180° to convert the blanks into half cylinders; placing the two half cylinders in edge to edge relationship to form a composite cylinder; temporarily embracing the composite cylinder with metal means to hold the composite cylinder together, said metal means having a lower co-efficient of thermal expansion than the metal of the composite cylinder; brazing the parts of the composite cylinder together to form a unitary cylinder with the lower co-efficient of said metal means resulting in constricting pressure in response to the heat involved in the brazing operation; removing the embracing metal means; and removing material from the interior and exterior of the composite cylinder to change the inside and outside diameters thereof to the inside and outside diameters of the desired tube.

2. A method of fabricating an accurately shaped and dimensioned transducer in the form of a tube of ferromagnetic material with a longitudinal gap in the magnetic material, including the steps of: providing two blanks for half cylinders, each of said blanks being of greater thickness than the desired thickness of the wall of the tube, each of said blanks being cylindrically curved with an

5

inside radius of curvature less than the inside radius of curvature of the desired tube and an outside radius of curvature greater than the outside radius of curvature of the desired tube, each of said sections being of greater than 180° in circumferential extent; removing material from the longitudinal edges of each of said blanks to form longitudinal edge faces in diametrical planes and to convert the blanks into half cylinders; placing the two half cylinders in edge to edge relationship with a thin spacer strip of non-magnetic material of uniform thickness between one pair of the matching edges to form a composite cylinder; holding the parts of the composite cylinder together under pressure to form a uniform gap between the two half cylinders at the spacer strip; bonding the parts of the composite cylinder together to form a unified cylinder; removing the holding pressure on the composite cylinder after the bonding operation; removing material from the interior and exterior of the unified cylinder to produce the desired inside and outside diameters of the transducer.

3. A method as set forth in claim 2 which includes the step of removing material from the exterior of the unitary tube along said gap to form a uniform gap face.

4. A method as set forth in claim 2 which includes the steps of magnetically annealing and straightening the two sections of cylinders prior to the step of removing material from the longitudinal edges thereof.

5. A method as set forth in claim 3 in which the steps of removing material to form said edge faces and said gap face are lapping operations.

6. A method of fabricating an accurately shaped and dimensioned transducer in the form of a tube of ferromagnetic material with a longitudinal gap in the magnetic material, including the steps of: providing two blanks for half cylinders, each of said blanks being of greater thickness than the desired thickness of the wall of the tube, each of said blanks being cylindrically curved with an in-

6

side radius of curvature less than the inside radius of curvature of the desired tube and an outside radius of curvature greater than the outside radius of curvature of the desired tube, each of said sections being of greater than 180° in circumferential extent; removing material from the longitudinal edges of each of said blanks to form longitudinal edge faces in diametrical planes and to convert the blanks into half cylinders; placing the two sections in edge to edge relationship with a thin spacer strip of non-magnetic metal of uniform thickness between one pair of the matching edges to form a composite cylinder; temporarily embracing the composite cylinder with metal means to hold the composite cylinder together, said metal means having a lower co-efficient of thermal expansion than the metal of the composite cylinder; brazing the parts of the composite tube together to form a unitary cylinder with the lower co-efficient of said metal means resulting in constricting pressure in response to the heat involved in the brazing operation; removing the embracing metal means; and removing material from the interior and exterior of the composite cylinder to reduce the inside and outside diameters thereof to the desired inside and outside diameters of the transducer.

7. A method as set forth in claim 6 in which the embracing step is accomplished by encircling the assembly with a coiled spring having a co-efficient of thermal expansion less than the co-efficient of the sections of cylinders.

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