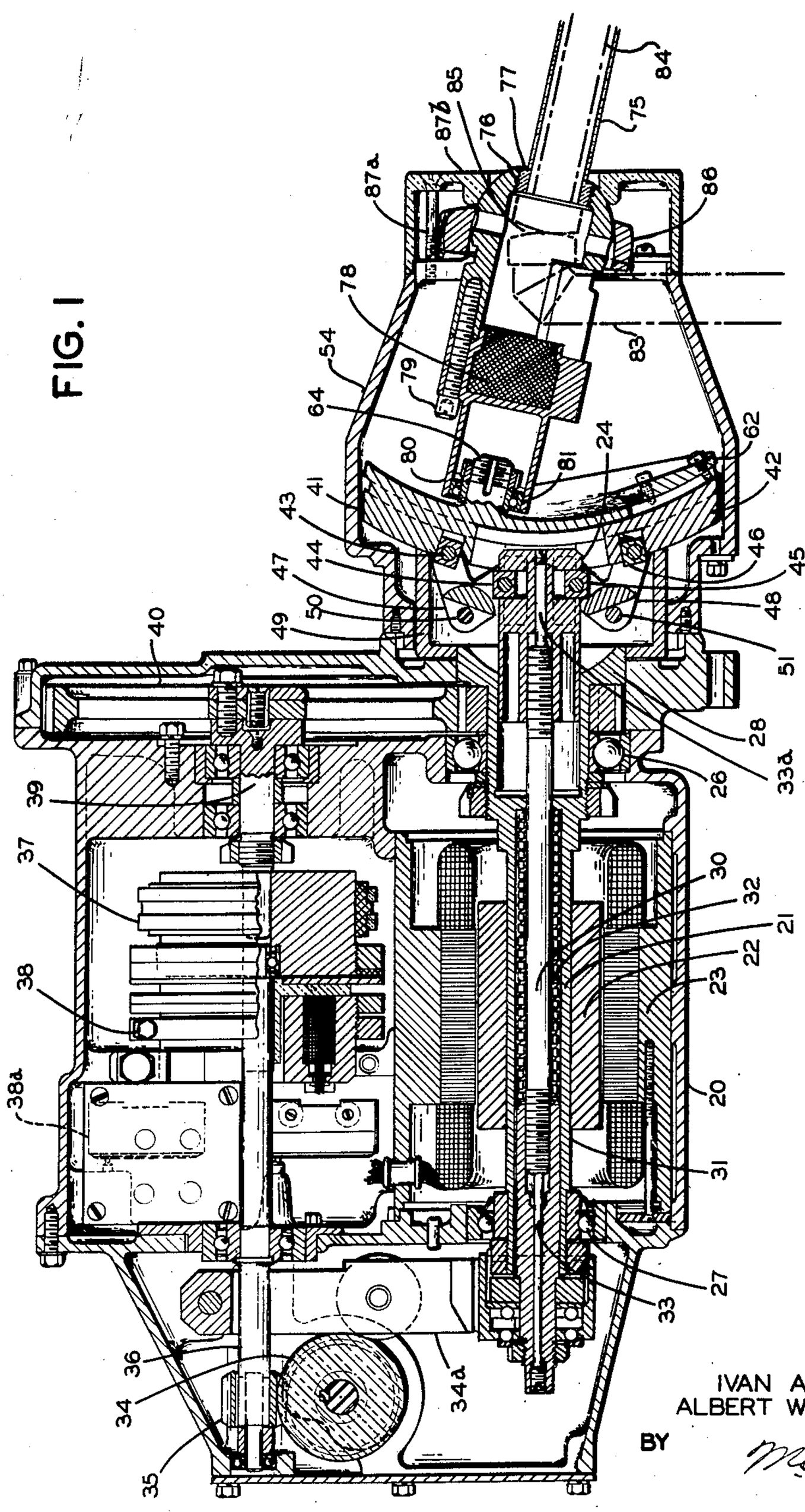
June 7, 1955 I. A. GETTING ET AL 2,710,352

SPIRAL SCAN ANTENNA MECHANISM

Filed Jan. 30, 1946 4 Sheets-Sheet 1

FIG. 1



INVENTOR
IVAN A. GETTING
ALBERT W. BELLAMY

BY M. O. Hayes

ATTORNEY

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SPIRAL SCAN ANTENNA MECHANISM

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FIG. 2

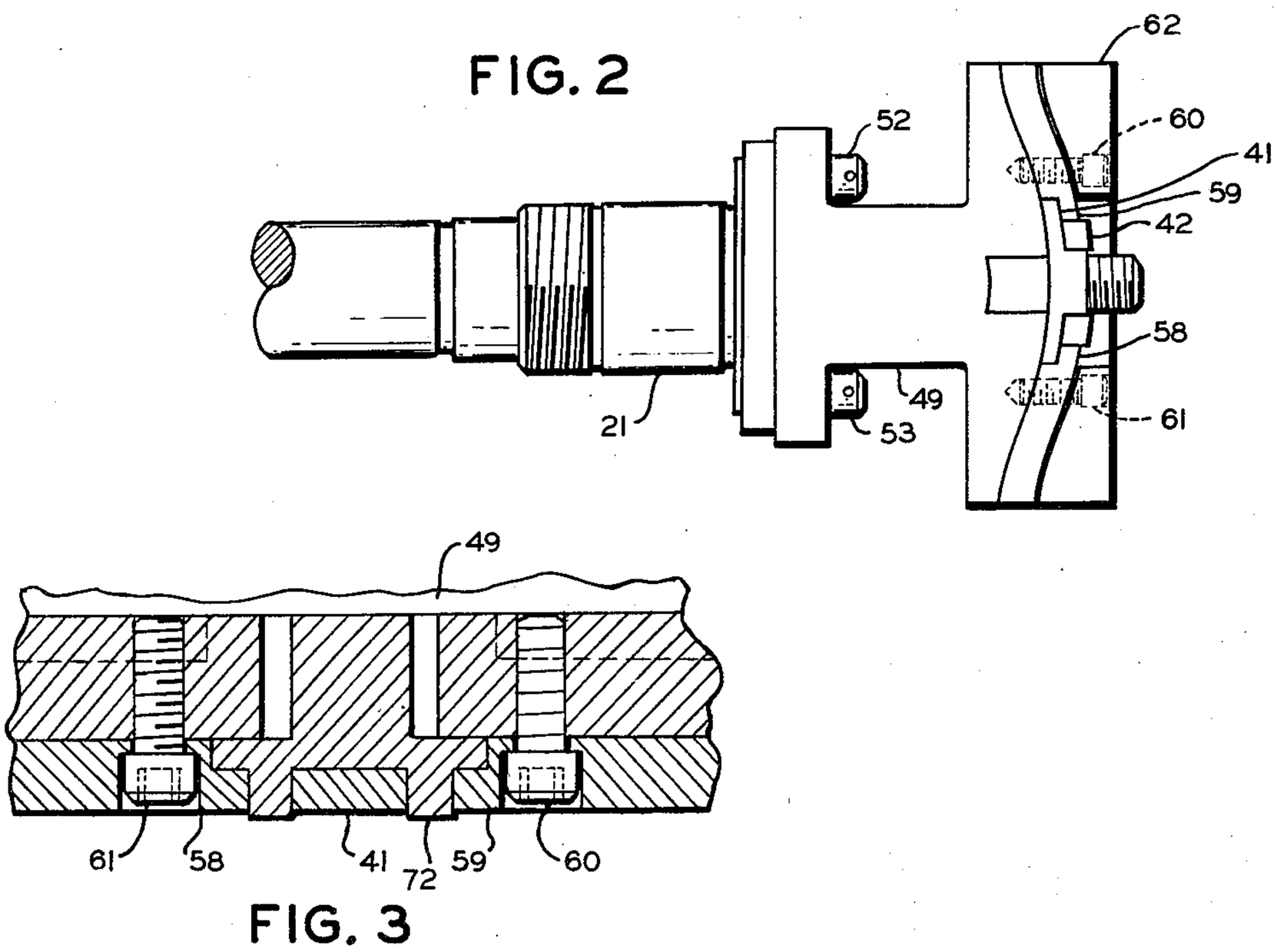

FIG. 3

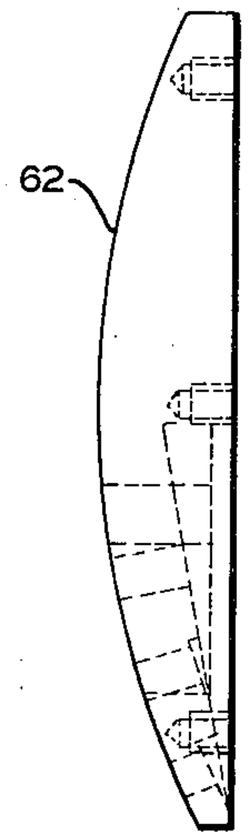

FIG. 5

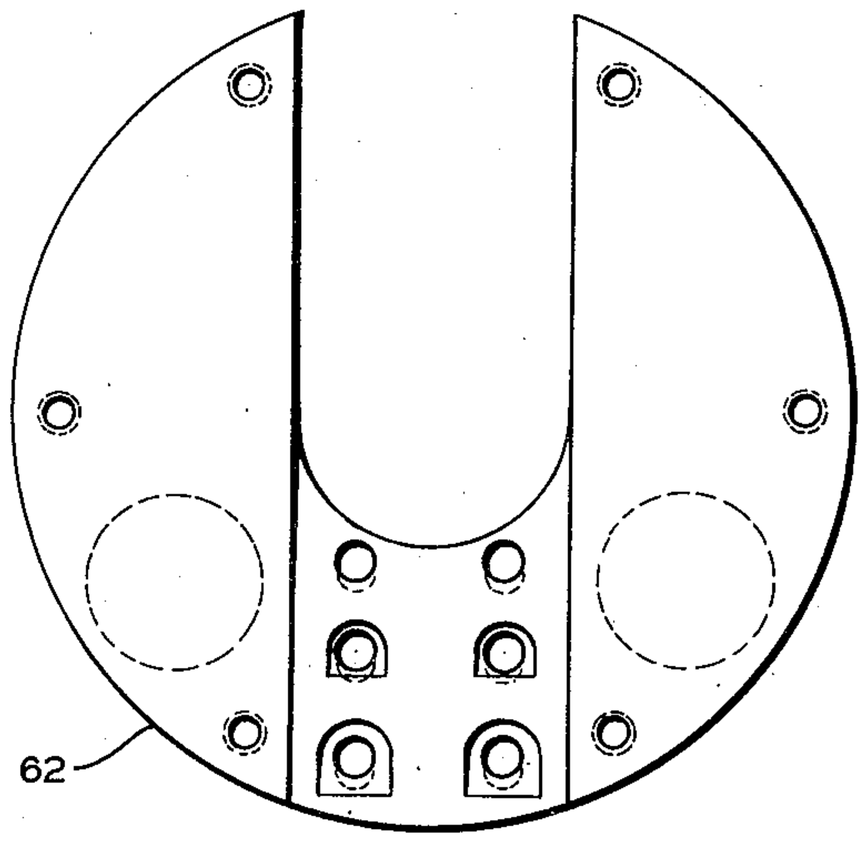

FIG. 4

INVENTOR
IVAN A. GETTING
ALBERT W. BELLAMY

BY M. A. Hayes

ATTORNEY

June 7, 1955 I. A. GETTING ET AL 2,710,352

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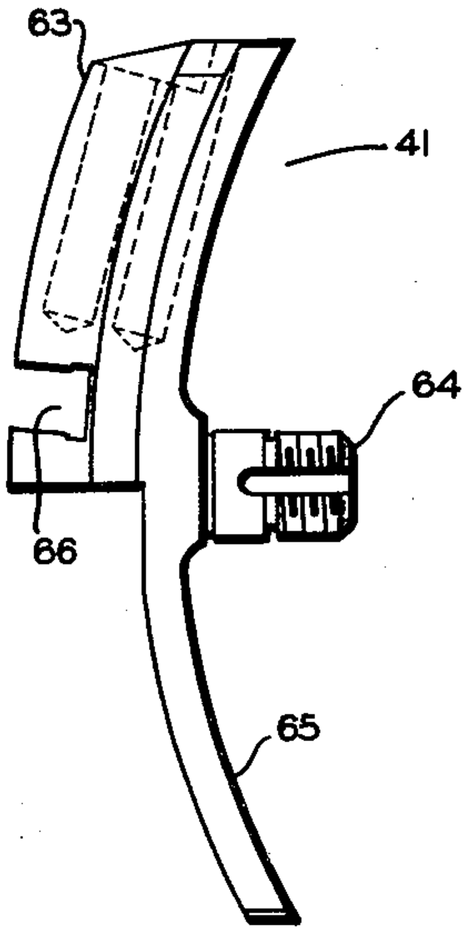

FIG. 6

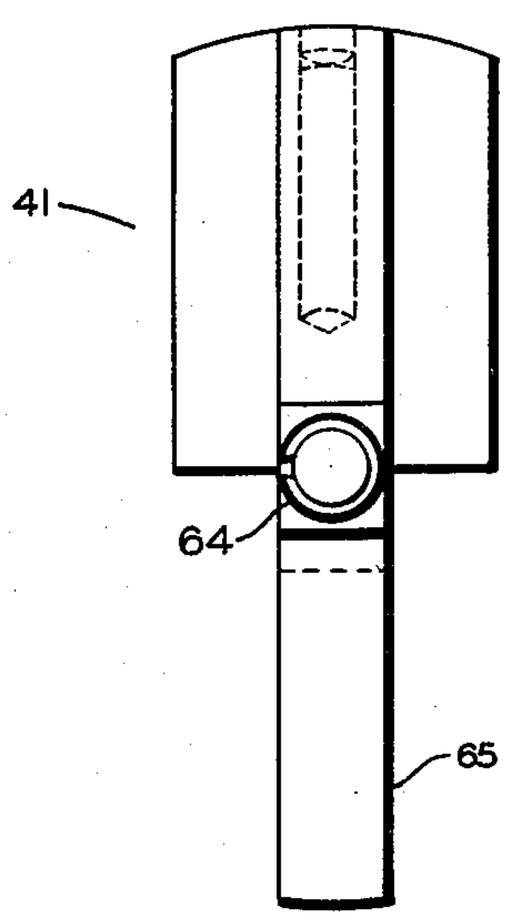

FIG. 7

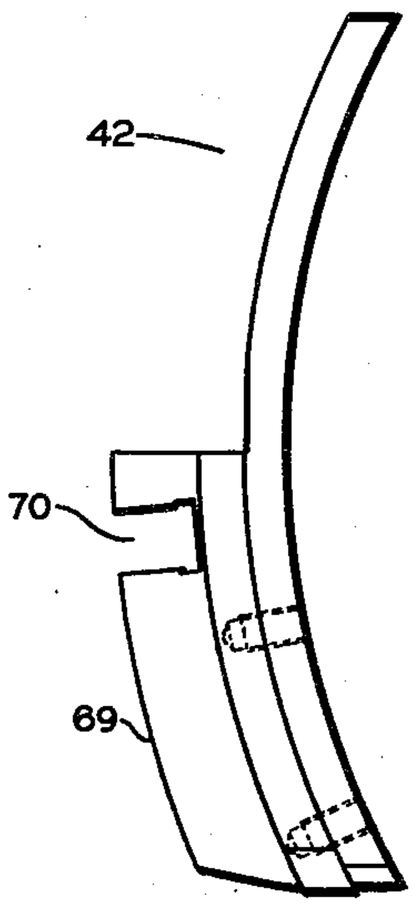

FIG. 8

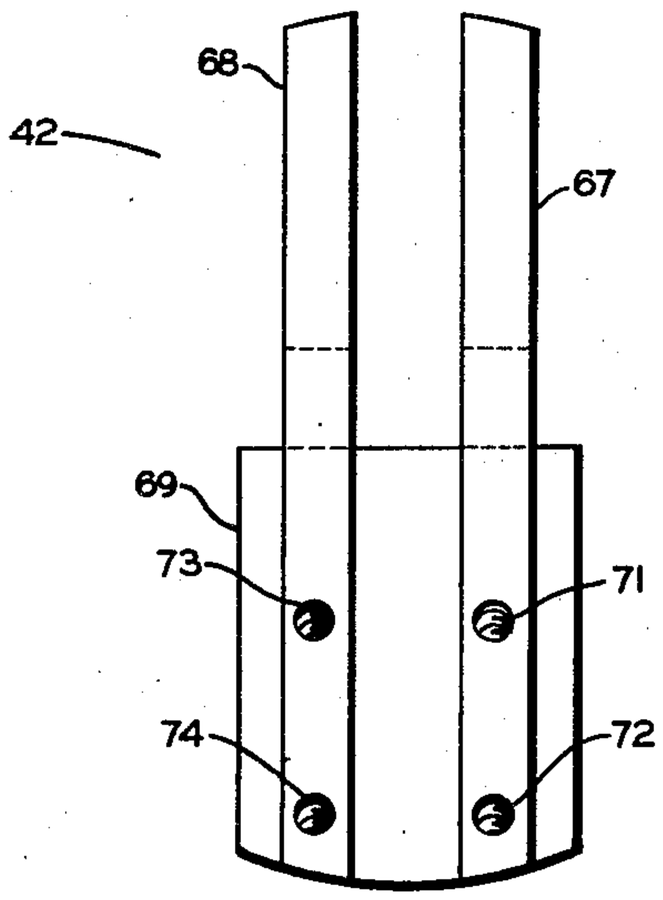

FIG. 9

INVENTOR
IVAN A. GETTING
ALBERT W. BELLAMY

BY M. Hayes

ATTORNEY

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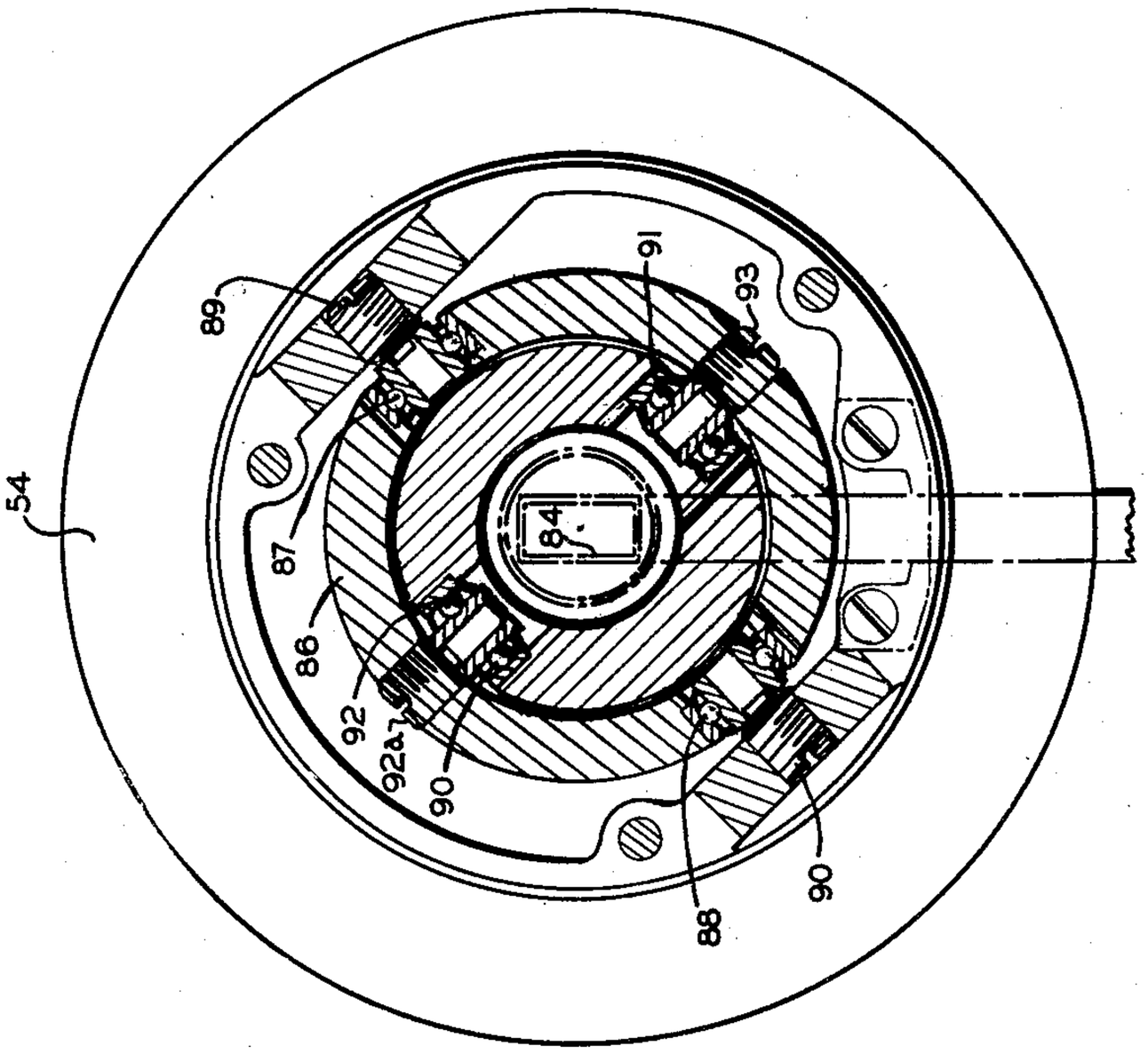

FIG. 11

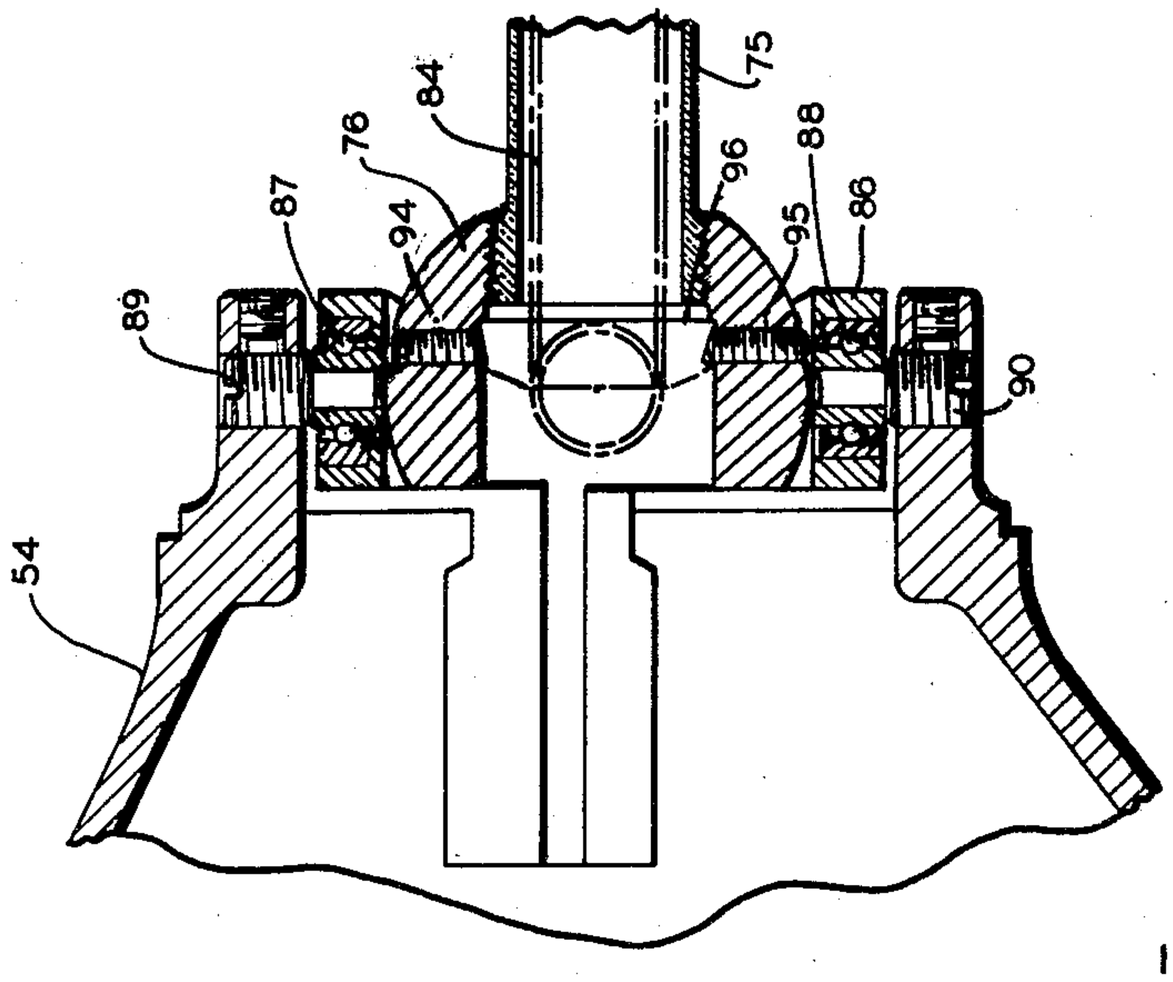

FIG. 10

INVENTOR
IVAN A. GETTING
ALBERT W. BELLAMY

BY M. O. Hayes

ATTORNEY

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SPIRAL SCAN ANTENNA MECHANISM

Ivan A. Getting, Belmont, Mass., and Albert W. Bellamy, North Hollywood, Calif., assignors, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Application January 30, 1946, Serial No. 644,395

17 Claims. (Cl. 250—33.63)

This invention relates to an antenna nutating scan mechanism, and more particularly to a mechanical drive for causing a wave guide, used to feed radio microwave energy to an antenna, to scan in either a spiral or conical pattern, and to maintain a beam of fixed polarization throughout the scanning cycle.

In the operation of radar mechanism of the type used for directing artillery fire against aircraft, and especially low flying aircraft such as torpedo planes, it is frequently desirable that the scan accomplished by the radar antenna be in a spiral pattern since such a pattern may be restricted to a relatively small area and will provide an accurate scan of the area encompassed by the spiral. My invention provides a mechanical assembly for causing the microwave transmission emitted from an antenna to assume either a conventional conical pattern, a spiral pattern, or other pattern, as may be found desirable.

An object of this invention is to provide an assembly for selectively providing a nutating spiral, conical, or other scan of radio microwave energy.

Another object of this invention is to provide an assembly for selectively providing a nutating spiral, conical or other scan of radio microwave energy in which the antenna feed and drive are so balanced as to bring the center of percussion of the antenna feed assembly at the point of connection of the antenna feed drive and the radially movable portion of the assembly.

Other objects and advantages of this invention as well as its construction, arrangement and operation will be apparent from the following description and claims in connection with the accompanying drawings in which:

Fig. 1 is a sectional view taken through a vertical center line of the assembly;

Fig. 2 is a plan view illustrating the spindle, chuck body, and jaw assembly;

Fig. 3 is a plan section through the screw holes of screws **60** and **61** of Fig. 2;

Fig. 4 is a front view of the counterweight shown in Fig. 1;

Fig. 5 is a side view of Fig. 4;

Fig. 6 is a front view of the pivot jaw;

Fig. 7 is a side view of Fig. 6;

Fig. 8 is a front view of the counterweight jaw;

Fig. 9 is a side view of Fig. 8;

Fig. 10 is a side view in section of the gimbal ring assembly of Fig. 1; and

Fig. 11 is a front view partially in section of the gimbal ring assembly of Fig. 1.

Referring to Fig. 1 there is shown a housing **20** containing a hollow spindle **21** which is pinned to the armature **22** of a suitable motor **23** and caused to rotate in bearings **26** and **27** in response to rotation of the armature. An enlarged portion **28** is provided on one end of spindle **21** as a means for mounting a chuck body **49**, hereinafter to be described, to spindle **21**. A shaft **30**, slidably mounted within hollow spindle **21**, is provided with a threaded hollow collar **31** on one end thereof for cooperation with a spring **32** which normally urges

the shaft towards an initial position. The opposite end of shaft **30** is fastened by means of screw threads to a draw plug **24** which is slidably mounted in the enlarged portion **28** of spindle **21** and which moves longitudinally in said portion in response to longitudinal motion of rod **30**. A pair of spacing pins **33** and **33***a* are provided at opposite ends of shaft **30** as a means for adjusting the initial setting of the shaft within hollow spindle **21**. A pivotally mounted cam lever **34***a* which cooperates with one end of shaft **30** to cause the rod to move longitudinally in hollow spindle **21** is actuated by a suitable cam **34** in such manner as to cause longitudinal reciprocatory motion of the rod. Cam **34** is driven by means of a suitable spur gear **35** having a shaft **36** extending therefrom and driven through conventional electric clutch and brake mechanisms **37** and **38** by a second shaft **39** which is, in turn, rotated by means of a gear train **40** connected to hollow spindle **21**. Cam **34** may, therefore, rotate in synchronism with the rotary motion of spindle **21** or may remain motionless as the spindle rotates by application of electromagnetic clutch and brake **37** and **38**. A control switch **38***a* is provided to selectively cause clutch **37** and brake **38** to be engaged and disengaged as may be desirable. When the cam rotates, cam lever **34***a* assumes a lateral and periodic motion, thus causing push rod **30** and draw plug **24** to assume a reciprocatory motion in order to vary the angle of tilt of a wave guide feed as hereinafter explained.

As shown, draw plug **24** is connected to a pivot jaw **41** and a counterweight jaw **42** by means of slide blocks **43**, **44**, **45** and **46** which are pinned to the opposite ends of a pair of bell crank levers **47** and **48**, the bell crank levers being pivotally mounted to a chuck body or flange **49** by means of a pair of pins **50** and **51**. Longitudinal movement of draw plug **24** causes bell cranks **47** and **48** to pivot about pins **50** and **51** thereby causing relative movement of pivot jaw **41** and counterweight jaw **42**, the jaws being simultaneously caused to move radially inwardly or outwardly depending upon the direction of the aforementioned longitudinal movement. The antenna feed and drive have been weighted by means of a counterweight **78** so as to bring the center of percussion of the antenna feed assembly at the point of connection of members **80** and **64** in order to minimize the strain at the center of oscillation of the wobble joint. In addition, the center of gravity of counterweight **62** presents an equal and opposite force at this point, thereby accurately and dynamically balancing the unit for all scan angles. As shown in Fig. 2, chuck body **49** is fastened to spindle **21** by means of a pair of screws **52** and **53** and is thereby caused to rotate in response to rotation of spindle **21**. Chuck body **49** acts as a retainer for holding pivot jaw **41** and counterweight jaw **42** in a slidable relationship.

Figs. 2 and 3 further illustrate the manner in which the counterweight and pivot jaws are slidably mounted upon and retained by chuck body. Referring to these figures, there is shown a pair of side plates **58** and **59** which are fastened to chuck body **49** by means of a pair of suitable screws **60** and **61**, the side plates being so formed as to provide an overlapping portion to slidably retain jaws **41** and **42** adjacent the chuck body. A counterweight plate **62** is fastened over the lower portion of counterweight jaw **42** as shown in Fig. 1. Figs. 4 and 5 demonstrate the general configuration of counterweight **62**, the counterweight comprising a U-shaped plate having the base portion partially cut away and provided with drilled holes for the placement of screws by which the counterweight is fastened to counterweight jaw **42** as shown in Fig. 1.

Figs. 6, 7, 8, and 9 illustrate the configuration of pivot jaw **41** and counterweight jaw **42**, respectively. Referring

to Figs. 6 and 7 pivot jaw **41** comprises a curved plate having a raised portion **63** extending from one side thereof and a threaded boss **64** extending from the opposite side thereof. A tongue **65** extends downwardly from the bottom of boss **64** to slidably engage a slotted portion of counterweight jaw **42**. Raised portion **63** is provided with a slot **66** to receive slide block **43** which causes the jaw to move radially in response to movement of bell crank lever **47**. As shown in Figs. 8 and 9, counterweight jaw **42** comprises a pair of curved tongues **67** and **68**, the tongues being spaced from each other to slidably receive tongue **65** of pivot jaw **41** therebetween. A block **69** is fastened to the tongues in the lower portion thereof, the block being provided with a slot **70** in order to receive slide block **46** which causes radial movement of the counterweight jaw in response to movement of bell crank lever **48**. Four threaded holes **71**, **72**, **73** and **74** are provided to receive screws used to fasten counterweight **62** to the lower portion of the jaw.

Further referring to Fig. 1, a wave guide support **75** is operatively connected to boss **64** of pivot jaw **41** by means of a choke housing or wave guide drive **76** and a counterweight **78**. Support **75** is connected to wave guide drive **76** by means of a screw thread **77**, while counterweight **78** is connected to the wave guide drive at one end by a suitable bolt **79** and to boss **64** at the other end by means of a cylindrical extension **80** which is fitted over a suitable bearing **81** secured to boss **64**. The wave guide consists of a fixed portion **83** and a movable portion **84**, the movable portion **84** thereof being mounted in support **75** and connected to the fixed portion **83** thereof by means of a suitable wobble joint **85**. In order to provide a universal joint for mounting support **75** in a gimbal support **54**, the wave guide drive **76** is mounted in a gimbal ring **86**. A cap **87***b* is mounted over gimbal ring **86** by means of 3 similar screws **87***a* to keep out dust and dirt. Further details of the method of mounting the wave guide support are illustrated in Figs. 10 and 11.

Figs. 10 and 11 are sectional views taken through gimbal ring **86**. Referring to the figures, gimbal ring **86** is mounted on gimbal support **54** by means of two suitable bearings **87** and **88** mounted on oppositely disposed studs **89** and **90** screwed into gimbal support **54**. The nose of wave guide drive **76**, on the other hand is fastened to gimbal ring **86** by similar bearings **91** and **92** mounted on oppositely disposed studs **92***a* and **93** fastened in the gimbal ring at ninety degrees from the axes of studs **89** and **90**. The movable portion **84** of the wave guide is retained within support **75** by means of a pair of set screws **94** and **95** which securely maintain a flange **96** of the wave guide within choke housing **76**. Flange **96**, in addition to providing a retaining means for securing section **84** of the wave guide within support **75**, constitutes a portion of the wobble joint connecting the fixed and movable portions of the guide.

In operation, it will readily be understood that wave guide section **84**, mounted within support **75** will assume the same scanning motion as that imparted to the support. As heretofore stated, support **75** is mounted in gimbal support **54** by means of a universal joint which allows support **75** and the external wave guide contained therein to assume a nutating or spiral motion as the radial distance of the axis of boss **64** from the axis of rotation of spindle **21** is varied by the action of cam **34** operating through shaft **30** to longitudinally move draw plug **24** and bell cranks **47** and **48**. That is to say, at all times when cam **34** is operative the wave guide within support **75** is caused to assume a spiral motion, but wherever cam **34** is inoperative (when clutch **37** is disengaged) the wave guide will follow a conical motion. Radio microwave radiation, which is fed into the fixed portion of the wave guide will assume a pattern in space as imparted to it by nutating spiral, or conical motion of the constantly nutating movable portion of the wave guide. While a particular cam is illustrated, it should be noted that cams

of various sizes and shapes may be used in order to vary the degrees of spiral patterns since this cam gives proper coverage of space being searched. When the cam is not in motion and spindle **21** is rotating a conical pattern will be realized. It will readily be understood that wave guide **84** may be used to feed a radio microwave reflector as may be found to be desirable.

While a particular embodiment of the invention has been disclosed and described, it is to be understood that various modifications and changes may be made therein without departing from the spirit and scope thereof as set forth in the appended claims.

What is claimed is:

1. An assembly for generating a spiral scan of radio microwave radiation comprising a wave guide having fixed and movable portions operatively connected by a wobble joint, a support, a gimbal system mounted on said support, a wave guide drive secured to the inner ring of said gimbal system, means for connecting said wave guide drive to the movable portion of said wave guide, a rotatable spindle, means for rotating said spindle, a flange on one end of said spindle, a shaft slidably disposed in said spindle having a draw plug on one end thereof, means for causing longitudinal motion of said shaft in response to rotation of said spindle, and means pivotally mounted on said flange operatively connecting said draw plug and said wave guide drive for causing radial movement of said wave guide drive in response to longitudinal movement of said draw plug.

2. A mechanism for generating a spiral scan of radio microwave radiation comprising a wave guide having fixed and movable portions operatively connected by a wobble joint, a support, a gimbal system mounted on said support, a wave guide drive secured to the inner ring of said gimbal system, means for operatively connecting the movable portion of said wave guide to said wave guide drive, a rotatable spindle having a chuck body on one end thereof, means for rotating said spindle, a shaft slidably mounted within said spindle having a draw plug secured thereto, a pivot jaw slidably mounted on said chuck body, means connecting said pivot jaw and said draw plug for causing radial movement of said pivot jaw in response to longitudinal movement of said draw plug, means for operatively connecting said pivot jaw to said wave guide drive, and means for causing reciprocatory motion of said shaft in response to rotation of said spindle.

3. A mechanical drive for generating a spiral scan of radio microwave radiation comprising a wave guide having fixed and movable portions operatively connected by a wobble joint, a support, a gimbal system mounted on said support, a wave guide drive having one end thereof fastened to the inner ring of said gimbal system, means for operatively connecting said movable portion of said wave guide to said wave guide drive, a housing, a spindle rotatably mounted in said housing, means for rotating said spindle, a shaft slidably mounted in said spindle, means for causing reciprocatory motion of said shaft in synchronism with rotation of said spindle, a chuck body mounted on said spindle, a bell crank lever pivotally mounted on said chuck body, means for operatively connecting said bell crank and said shaft, and means for operatively connecting said bell crank and said wave guide drive.

4. A mechanical drive for generating a spiral scan of radio microwave radiation comprising a wave guide having fixed and movable portions operatively connected by a wobble joint, a support, a gimbal system mounted on said support, a wave guide drive having one end thereof fastened to the inner ring of said gimbal system, means for operatively connecting the movable portion of said wave guide to said wave guide drive, a housing, a spindle rotatably mounted in said housing, means for rotating said spindle, a shaft slidably mounted in said spindle, means for causing reciprocatory motion of said shaft in synchronism with rotation of said spindle, a draw

plug fastened to said shaft, a chuck body mounted on said spindle, a bell crank lever pivotally mounted on said chuck body, means for operatively connecting said draw plug and said bell crank, and means for operatively connecting said wave guide drive and said bell crank.

5. An assembly for generating a spiral scan of radio microwave radiation comprising a wave guide having fixed and movable portions operatively connected by a wobble joint, a support, a gimbal system mounted on said support, a wave guide drive having one end thereof fastened to the inner ring of said gimbal system, means for connecting the movable portion of said wave guide and said wave guide drive, a rotatable spindle, means for rotating said spindle, a chuck body fastened to one end of said spindle, a pivot jaw slidably mounted in said chuck body, a shaft slidably disposed in said spindle having a draw plug fastened thereto, means for operatively connecting said wave guide drive and said pivot jaw, means for causing longitudinal movement of said shaft in response to rotation of said spindle, and means connecting said pivot jaw and said draw plug for causing radial movement of said pivot jaw in response to longitudinal movement of said draw plug.

6. An assembly for selectively providing spiral and conical scan of radio microwave radiation comprising a wave guide having fixed and movable portions operatively connected by a wobble joint, a support, a gimbal system mounted on said support, a wave guide drive having one end thereof fastened to the inner ring of said gimbal system, means for connecting said wave guide drive to the movable portion of said wave guide, a rotatable spindle having a chuck body fastened to one end thereof, means for rotating said spindle, a shaft slidably disposed in said spindle having a draw plug fastened to one end thereof, a pivot jaw slidably mounted upon said chuck body, a bell crank lever pivotally mounted on said chuck body for operatively connecting said pivot jaw and said draw plug, means for operatively connecting said wave guide drive and said pivot jaw, a cam, an arm operatively connecting said cam and said shaft, driving means for rotating said cam in synchronism with rotation of said spindle, and clutch and brake disposed in said driving means for selectively causing said cam to rotate and be held in a fixed position.

7. An assembly for providing spiral and conical scan of radiation comprising a conductor having fixed and movable portions, a support, a gimbal system mounted on said support, a conductor drive mechanism having one end fastened to the inner section of said gimbal system, means connecting said drive mechanism to said movable portion of said conductor, a rotatable spindle, means for rotating said spindle, a flange on one end of said spindle, a shaft slidably disposed in said spindle having a draw plug in one end thereof, means for causing longitudinal motion of said shaft, and means on said flange operatively connecting said draw plug and said conductor drive mechanism.

8. In apparatus for providing spiral and conical scan of radiation, the combination comprising first and second wave guide sections, said first section being fixed, the second of said sections being movably supported in end to end relationship with said first section, a universal joint system, means securing said second section to said universal joint system, and means connected to said universal joint system for imparting nutating motion to said second section through said universal joint system, whereby said second section nutates about the adjacent end of said first section.

9. In apparatus for providing spiral and conical scan of microwave radiation the combination comprising, a conductor having fixed and movable portions in end to end relationship, said fixed and movable portions being operatively connected by a wobble joint, a support, universal joint means mounted on said support, means securing said movable portion to said universal joint means

whereby said movable portion is capable of assuming a nutating motion about said fixed portion, and means including drive means operatively coupled to said universal joint means for nutating said movable section about said fixed section.

10. In apparatus for providing spiral and conical scan of microwave radiation, the combination comprising, a conductor having fixed and movable portions in end to end relationship, said fixed and movable portions being operatively connected by a wobble joint, a support, a gimbal system mounted on said support, means securing said movable portion to said gimbal system whereby said movable portion is capable of nutating motion about said fixed portion, means connected to said gimbal system for imparting nutating motion to said fixed portion, and drive means connected to said last-mentioned means.

11. An assembly for providing spiral and conical scan of radiation comprising, a hollow shaft, drive means for rotating said shaft, a wobble joint having a fixed portion and a movable portion, first wave guide means secured to said fixed portion, second wave guide means secured to said second portion, means including a universal joint connecting said shaft to said movable portion of the wobble joint, said connecting means acting to convert the rotating motion imparted to it by said shaft to a nutating motion, said mutating motion being applied by said universal joint means to said second wave guide means.

12. An assembly as described in claim 11 wherein said connecting means includes means for selectively varying the angle of tilt of said second wave guide means.

13. An assembly as described in claim 12 further including cam operated means for controlling operation of said means for varying the tilt of said second wave guide means, whereby said second wave guide means may be spirally nutated.

14. A mechanism comprising in combination, a hollow rotatable spindle, means for driving said spindle, a flange on one end of said spindle, a shaft slidably disposed on said spindle having a draw plug in one end thereof, a pivot jaw, lever means pivotally mounted on said flange slidably connecting said draw plug and said pivot jaw and adapted to cause radial movement of said pivot jaw in response to longitudinal movement of said draw plug.

15. Apparatus as in claim 14 further including a gimbal support, a gimbal system comprising first and second annular elements, said gimbal system being pivotally secured to said support by said first annular element, means rotatably securing said second annular element to said pivot jaw, a wave guide support secured to said second annular element, and a wave guide secured by said wave guide support in axial alignment with said second annular element, whereby said wave guide is caused to assume a rotating and nutating motion which is a function of the speed at which the spindle is driven and the radial position of said pivot jaw.

16. The combination comprising a hollow rotatable spindle having an enlarged portion at one end thereof, means for driving said spindle, a push rod slidably mounted within said spindle, a draw plug fastened at one end of said push rod and slidably mounted in the enlarged end of said spindle, flange means fixedly secured to said spindle at said enlarged end, a pivot jaw, bell crank lever means pivotally mounted on said flange means, the ends of said bell crank lever means being connected by slide blocks to said draw plug and said pivot jaw, and means for moving said push rod longitudinally whereby said pivot jaw is radially displaced by said bell crank lever means, a wave guide section, and means for imparting nutatory motion to said wave guide section operatively coupling said pivot jaw to said wave guide section, whereby said wave guide section assumes a nutatory motion in synchronism with rotation of said spindle.

17. An assembly for providing spiral and conical scan of radiation comprising, a hollow shaft, means for rotat-

ing said shaft at a predetermined rate, a chuck body mounted on one end of said shaft and rotatable therewith, a pivot jaw slidably mounted on said chuck body and rotatable therewith, means slidably mounted within said hollow shaft and connected to said pivot jaw for causing radial movement of said pivot jaw, a wave guide section, a universal joint system having a movable portion thereof secured to said wave guide section, and means connecting said universal joint system to said pivot jaw, whereby said universal joint system imparts rotating and nutating motion to said wave guide section, the rotating motion of said wave guide section being a function of the rotating motion of said hollow shaft,

said nutating motion of said wave guide section being a function of the radial displacement of said pivot jaw.

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