United States Patent [19]

Teach

[11] **3,825,808**

[45] **July 23, 1974**

[54] **SIGNAL-SEEKING, POWER-DRIVEN MAST FOR USE IN LASER BEAM CONTROLS AND SURVEYING SYSTEMS**

[75] Inventor: **Ted L. Teach,** Springfield, Ohio

[73] Assignee: **Lasserplane Corporation,** Dayton, Ohio

[22] Filed: **May 10, 1973**

[21] Appl. No.: **358,881**

[52] **U.S. Cl.** **318/266,** 318/468

[51] **Int. Cl.** **G05d 3/04**

[58] **Field of Search** 318/266, 267, 468

[56] **References Cited**

UNITED STATES PATENTS

3,002,598	10/1961	Hoover	318/468 X
3,341,760	9/1967	Fry	318/266 X

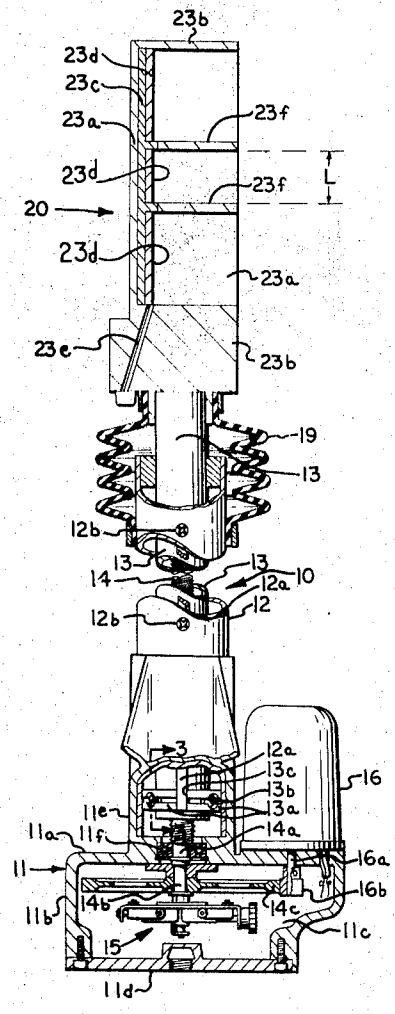
Primary Examiner—Robert K. Schaefer
Assistant Examiner—W. E. Duncanson, Jr.
Attorney, Agent, or Firm—W. A. Schaich

[57] **ABSTRACT**

This invention relates to the construction of a power-driven extensible mast for mounting a photocell unit which is utilized to detect a laser beam which is periodically swept over a working area at a known elevation. Suitable circuits are provided between the photocell unit carried by the extensible mast and a motor unit which effects the raising and lowering of the mast to automatically maintain the mast at a height corresponding to exact vertical alignment with the photocell unit with the laser beam.

Another feature of the invention is the provision of automatic limit switch means which function to reverse the direction of the driving motor when the mast reaches either the top or bottom extremity of its vertical movement.

3 Claims, 6 Drawing Figures



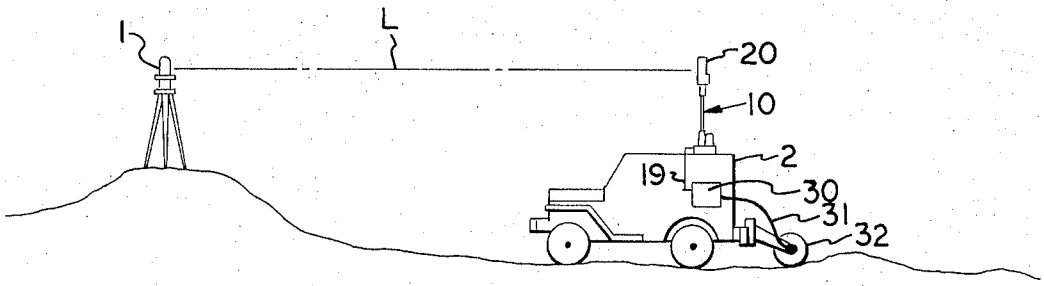


FIG. 1

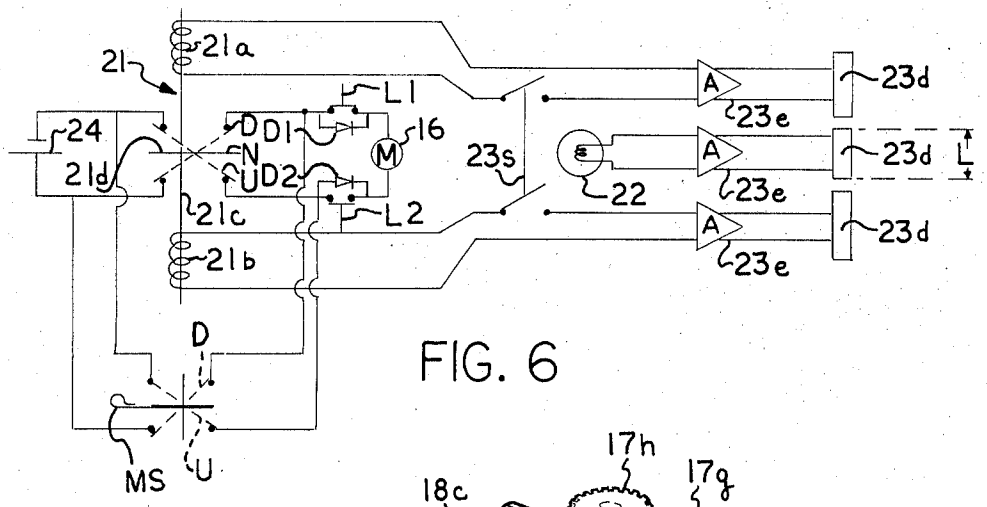


FIG. 6

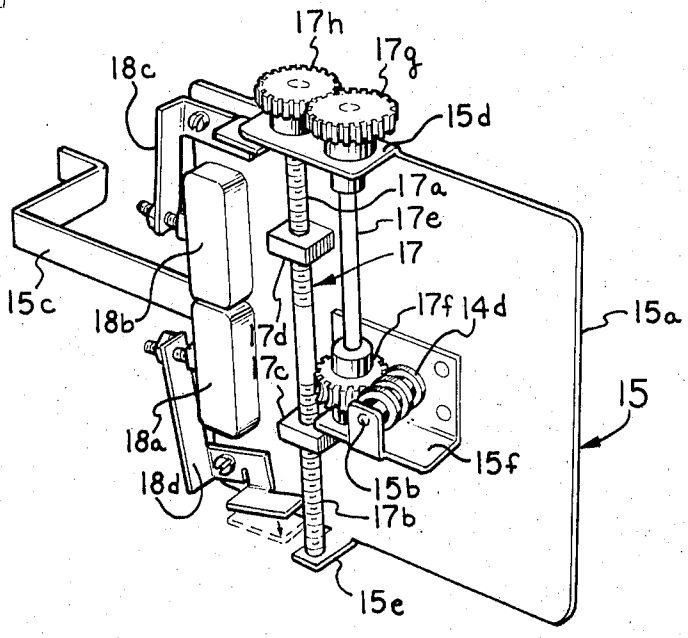


FIG. 5

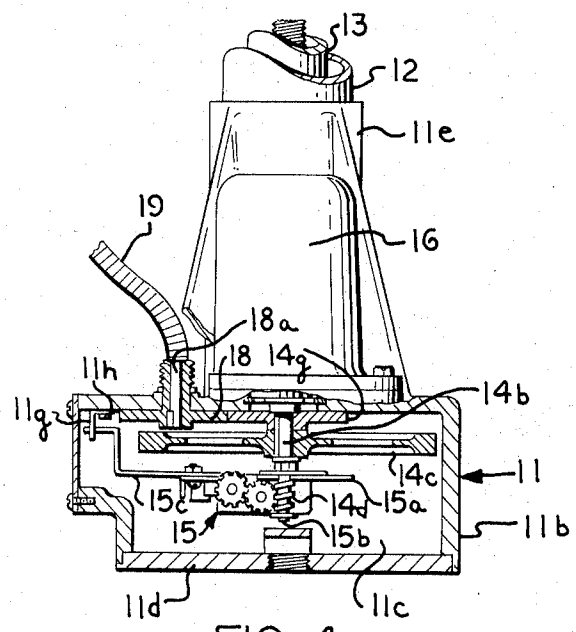


FIG. 4

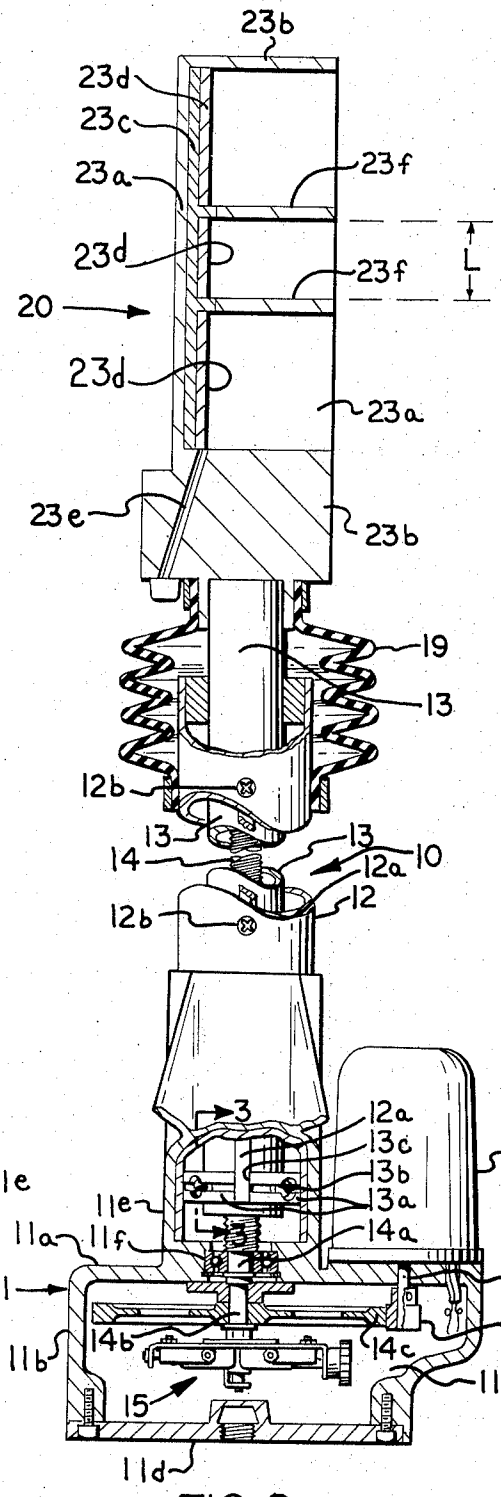


FIG. 2

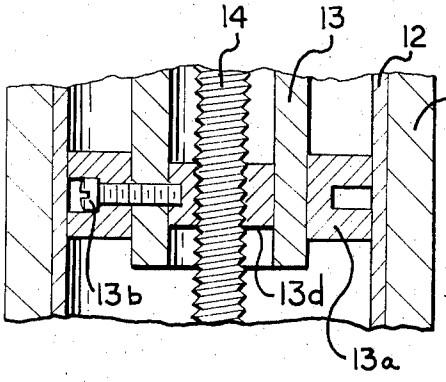


FIG. 3

SIGNAL-SEEKING, POWER-DRIVEN MAST FOR USE IN LASER BEAM CONTROLS AND SURVEYING SYSTEMS

BACKGROUND OF THE INVENTION

In U.S. Pat. No. 3,588,249, issued to Robert H. Studebaker, there is disclosed and claimed apparatus for generating a laser beam reference plane by periodically sweeping a laser beam over a working area. In U.S. Pat. No. 3,494,426, also issued to Robert H. Studebaker, there is disclosed a control apparatus for graders and similar earthworking implements which employs a laser beam responsive photocell unit mounted on a vertical mast, and the signals generated by such photocell unit are effectively utilized to control the working height of the blade of the grader.

In said last-mentioned Studebaker patent, the vertical mast is mounted on the same movable frame as carries the blade of the grader and the vertical mast is extensible or retractible only by a manual mechanism and only for the purpose of initially aligning the photocell unit with the laser beam.

As new applications for the laser beam control system disclosed and claimed by said Studebaker patents have become apparent, it has become equally apparent that there is a need for a power-driven, signal-seeking, extensible mast for mounting a laser beam responsive photocell unit, which mast may be mounted on any vehicle traversing uneven terrain and the effective height of such mast can be automatically controlled, through signals generated by the photocell unit, to maintain the photocell unit in exact vertical alignment with the laser beam. The resulting vertical movements of the mast may be utilized to control the effective working height of an earthmoving instrument, such as the blade of a scraper or bulldozer, or, as disclosed and claimed in my copending application Ser. No. 358,835, filed concurrently herewith, such vertical movements of the power-driven, signal-seeking mast may be recorded as a function of the distance traversed by the vehicle to automatically provide an elevational contour of the terrain traversed by the vehicle.

Accordingly, it is an object of this invention to provide an improved power-driven, extensible mast structure for mounting a laser beam responsive photocell unit.

A particular object of this invention is to provide a power-driven, extensible mast for mounting a laser beam responsive photocell unit, wherein the vertical movements of the mast may be controlled by signals generated by the photocell unit to maintain the photocell unit in exact vertical alignment with a laser beam that is periodically swept over a working area at a known elevation.

Still another particular object of this invention is to provide an improved, power-driven, extensible mast construction, including automatic limit stops and a secondary indicating shaft which is rotated in linear relationship with the vertical movements of the mast to provide a mechanical signal of such movements which may be employed to operate a recording or control device.

Other objects and advantages of this invention will become apparent from the following description, taken in conjunction with the annexed sheets of drawings on which:

FIG. **1** is a schematic, side elevational view of a laser beam transmitter and a vehicle carrying a power-driven variable-height mast and a laser beam responsive photocell on top of said mast.

FIG. **2** is an elevational view partly in section of the vertically adjustable mast and photocell unit.

FIG. **3** is an enlarged scale, partial sectional view taken on the plane **3—3** of FIG. **2.**

FIG. **4** is an elevational view of the lower portions of the mast of FIG. **2** with positions in section.

FIG. **5** is an enlarged scale perspective view of the mast limit switch mechanism.

FIG. **6** is a circuit diagram of the mast height control system.

Referring to FIG. **1,** there is schematically illustrated a basic surveying or control system utilizing the principles of laser beam control disclosed and claimed in U.S. Pat. No. 3,588,249. A laser beam transmitter **1,** of the type disclosed in said patent, is mounted at a point on the terrain where the elevation is known and adjusted to periodically sweep a laser beam L over the adjacent terrain. The position of the moving laser beam is adjusted to lie exactly in a horizontal plane which, obviously, will be at a known elevation. The laser beam L is then detected by equipment carried by a vehicle **2** moving over the terrain. Vehicle **2** may, as shown in this application, constitute a Jeep and be utilized for surveying purposes.

A signal-seeking, automatically vertically adjustable mast **10** is carried by the vehicle **2,** and on the top of the mast **10** a photocell unit **20** is mounted which is responsive to the laserbeam L. Signals generated by the photocell unit **20** are then utilized to control the effective height of the adjustable mast **10** to keep the center of the photocell unit **20** in exact vertical alignment with the reference plane defined by the laser beam L.

The resulting vertical movement of the adjustable mast **10** may then be converted to a horizontal or mechanical signal which, if recorded, automatically provides a plot of the elevation of the terrain traversed by the vehicle **2.**

Referring now to FIG. **2,** the vertically adjustable mast **10** comprises an inverted cup-shaped mounting base **11** having a top horizontal wall **11***a* and a depending peripheral flange **11***b* defining a power transmission chamber **11***c*. The bottom of chamber **11***c* may be conveniently closed by a mounting plate **11***d* which can be utilized to mount the mast on the vehicle **2.** An upstanding cylindrical wall **11***e* is integrally formed on the base **11** and a tubular housing **12** of substantial axial extent is anchored in said cylindrical wall.

A tubular mast **13** is then slidably mounted in the housing **12.** The housing **12** is provided with a plurality of axially extending ribs **12***a* secured to its inner surface by a plurality of bolts **12***b*. At the lower portion of mast **13,** a plurality of annular segments **13**a are secured thereto by screws **13***b* and the spaces between said annular segments define grooves **13***c* which slidably cooperate with the guide ribs **12***a* provided on housing **12.** Thus mast **13** may be slidably moved upwardly or downwardly relative to housing **12** but cannot be rotated.

A circular nut **13***d* (FIG. **3**) is then provided in the bottom end of mast **13** and may be secured therein by the same bolts **13***b* as are utilized to secure the annular segments **13***a* to the mast **13.**

A mast height adjusting screw **14** is provided comprising an elongated rod which is threaded over the major portion of its length but has a cylindrical section **14***a* adjacent its bottom portion which is journalled in a bearing **11***f* provided in the horizontal wall **11***a* of the base **11.** The extreme lower end **14***b* of the screw **14** extends into transmission chamber **11***c* and mounts a limit switch mechanism **15** which will be hereinafter described in detail.

A reversible driving motor **16** is mounted on the horizontal wall **11***a* of base **11** and has its output shaft **16***a* projecting downwardly into the transmission chamber **11***c*. While in the specific example illustrated in the drawings, motor **16** is shown as being electrical, it will be obvious to those skilled in the art that an air or hydraulic motor could be equally utilized, depending upon the power available on the particular vehicle **2** on which the mast is mounted.

A frictional driving pinion **16***b* is secured to the motor shaft **16***a* and frictionally engages the periphery of a substantially larger friction gear **14***c* which is mounted on and keyed to the lower portion **14***b* of the mast type adjusting screw **14.** It is therefore apparent that, depending upon the direction of rotation of the motor **16,** the effective height of mast **13,** and hence the effective height of photocell unit **20** carried by the top of such mast, may be raised or lowered.

In order to prevent the raising or lowering movements of the mast **13** from exceeding the extremities of the adjusting screw **13,** a limit switch mechanism **15** is provided (FIG. **5**) comprising a horizontal plate **15***a*, on the bottom of which is mounted a bracket **15***f*. A vertical stub shaft **15***b* is journalled in bracket **15***f* and is threadably secured to the bottom end **14***b* of the adjusting screw **14.** A worm-type drive pinion **14***d* is secured to stub shaft **15***b* and rotates with screw **14,** but plate **15***a* is prevented from rotating by a projection **15***c* which is engaged by a U-shaped bracket **11***g* secured to base **11** by a bolt **11***h*. A limit switch actuating rod **17** is journalled in horizontal relationship below the bottom surface of plate **15***a* by brackets **15***d* and **15***e* and rod **17** has threaded end portions **17***a* and **17***b* respectively engaging internally threaded switch actuating nut blocks **17***c* and **17***d*. The actuating rod **17** is rotated in proportion to the vertical movements of the mast **13** through a speed reduction gear train comprising an intermediate shaft **17***e* also journalled between brackets **15***d* and **15***f* in horizontal relationship below the bottom of plate **15***a* and carrying on one end a pinion **17***f* which is engaged by the drive worm **14***d*. The other end of intermediate shaft **17***e* carries a drive pinion **17***g* which meshes with a corresponding pinion **17***h* mounted on the end of the limit switch actuating rod **17.**

A pair of limit switches **18***a* and **18***b* are mounted in side-by-side relationship adjacent to the path of movement of the actuating blocks **17***c* and **17***d*. At their respective extremes of travel, the actuating blocks **17***c* and **17***d* respectively contact right-angle shaped pivotally-mounted limit switch actuators **18***c* and **18***d*. The entire mechanism is adjusted so that the actuating block **17***c* effects the actuation of limit switch **18***a* to open same when tubular mast **13** reaches the maximum height permitted by the length of screw **14,** while actuating block **17***d* effects the actuation of limit switch **18***b* to open same when the tubular mast **13** is lowered to the minimum height permitted by the actuating screw **14.**

Referring now to FIG. **2,** there is shown a preferred form of construction of the photocell unit **20** which is mounted on the top of the adjustable mast **10.** Photocell unit **20** comprises a housing **23** having three vertical walls **23***a* and top and bottom walls **23***b*. An accordian-type dust shield **19** interconnects the bottom wall **23***b* and the top of housing **12.** Mounting plate **23***c* is positioned in the housing **23** opposite its open vertical side and a plurality of laser beam responsive cells, here shown as three vertically aligned units **23***d*, are mounted in a suitable vertically spaced recess in the plate **23***c*. Such cells **23***d* may comprise any known device that will generate a voltage or change its electrical properties when a laser beam is incident thereon. Selenium or silicon photocell units are preferred. Thin horizontal light shields or spacers **23***f* are provided between the center photocell unit **23***d* and the two vertically adjacent cells.

Electrical leads **23***e* connect each of the photocells **23***d* to a suitable amplifying unit A (FIG. **6**) which are preferably mounted in some protected location within the vehicle **2.**

It is important that the total height of the central photocell unit **23***d* be at least equal to the minimum thickness or height of the laser beam **5** at all points within the effective working area traversed by the beam. This insures that at any time the optical center of this central photocell unit **23***d* departs from a position of exact vertical alignment with the center of the incident laser beam L, one or the other of the two vertically adjacent photocell units **23***d* will be energized to a greater or lesser extent. In other words, the vertical spacing between top and bottom photocell units **23***d* should not be greater than the minimum vertical thickness of the laser beam L at any point in the desired working area and the effective working heights of each of the top and bottom photocell units **23***d* should be at least 2 to 6 inches so that no normal changes in elevation of the vehicle **2** produced by the terrain will cause the photocell beam L to completely escape detection by the photocell unit **20** before correction of the mast height is initiated.

As previously indicated, the amplifying devices A (FIG. **6**) are entirely conventional and translate the signals generated by each respective photocell unit **23***d* by any incident laser beam excitation into a usable electrical signal. The signal generated by the central photocell unit **23***d* and its associated amplifier A may be conveniently utilized to energize an indicating light **22** which is appropriately located within the vehicle **2** so that it is observable by the operator. So long as light **22** is energized, the operator is assured that at least a portion of the central photocell unit **23***d* is aligned with the laser beam L.

The amplified signals from the top and bottom photocell unit **23***d* are applied, through a manually-operable disconnect switch **23***s*, in opposing relationship to a conventional reversible solenoid switch **21.** Switch **21** comprises energizing coils **21***a* and **21***b* which are respectively energized in opposite directions by the amplifiers A connected to the top and bottom photocell units **23***d*. Whenever the current flowing in one of the coils is stronger than that flowing in the opposite coil, then the movable core **21***c* of the reversible solenoid **21** is shifted to effect a reversal of the polarity of the D. C.

electrical power source **24** that is connected to the mast adjusting motor **16.**

In the neutral position of the reversible solenoid switch **21,** the switch-actuating bar **21***d* is disposed in the solid line or neutral position N, wherein the power source **24** for reversible motor **16** is not connected to the motor. Let us assume that the vehicle **2** enters terrain that is sloping downwardly relative to the reference plane defined by the laser beam L. In that event, the upper photo cell unit **23***d* will be energized by the laser beam L and no energization will be imposed on the lower photocell unit **23***d*. The differential solenoid switch **21** will then have its upper coil **21***a* energized more strongly than the lower coil **21***b* and the core **21**c will shift upwardly, moving the switch actuator **21***b* to the position shown in dotted lines and labeled "U," meaning that the D. C. source **24** will be connected to drive motor **16** in such a direction that the motor **16** will raise the mast **10** to bring the center of the photocell unit **20** into alignment with the center of the laser beam L. Such upward movement will continue until substantial equal energization of the upper and lower photocell units **23**d will be produced which will effect the operation of the solenoid switch **21** to return it to its neutral position N, and the motor **16** will then be effectively deenergized.

Referring particularly to FIGS. **5** and **6,** the contacts of the limit switches **18***a* and **18***b* are illustrated in the circuit diagram as the switch elements L1 and L2. It will therefore be apparent that the operation of either of the switches L1 or L2 to their open position will effectively stop the energization of the motor **16.** In order that the motor **16** can thereafter be energized in the opposite direction, a pair of diodes D1 and D2 are each connected across the contacts of the switches L1 and L2 in customary fashion.

Lastly, it is often desirable to provide for manual operation of the reversible motor **16** in order to initially position the mast **10** at an appropriate height to center the photocell unit **20** on the laserbeam L. Such manual operation may be effected by opening of switch **23***s* and manipulation of the manual switch MS, shown schematically in FIG. **6,** between either of the dotted line positions. In the one position labeled "D," the manual switch MS will effect the energization of the motor **16** to lower the mast. In the other position labeled "U," the motor **16** will be energized in the opposite direction to raise the mast. In either case, the mast height is manually controlled until the indicating light **22** is energized which tells the operator that the photocell unit **20** is then vertically aligned with the laser beam L.

In many applications of the signal-seeking, adjustable mast **10,** it is desirable to derive a mechanical or electrical signal proportional to the height of the mast. Referring to FIG. **4,** such mechanical signal may be conveniently provided by mounting a pinion gear **14***g* on the lower end of the adjustment screw **14** and permitting such pinion to drive a gear **18** which is mounted on the end of a hollow shaft **18***a* which is appropriately journalled in the top wall **11***a* of the base **11.** The shaft **18**a is appropriately provided with a hexagonal-shaped interior cavity to receive the correspondingly shaped end of a flexible shaft **19** which will transmit the rotations of the shaft **18***a* to a remote point where such rotations can continuously provide a mechanical signal of the effective height of the adjusable mast **10.**

In the specific application of this invention to an automatic elevation recording device, as illustrated in FIG. **1,** the flexible shaft **19** is connected to drive one component of a mechanical recorder **30,** for example, the abscissa or vertical component. The horizontal component of motion is supplied to the recorder **30** by a speedometer cable **31** which is driven by a bicycle wheel **32** which is trailed behind the vehicle **2.** Conventional gearing (not shown) is provided in between the bicycle wheel **32** and shaft **31** so that the rotation of flexible shaft **31** is exactly proportional to the distance travelled by the vehicle **2.** Thus, the stylus (not shown) of the recorder **30** will reproduce a trace which shows the elevation of the terrain traversed by the vehicle **2** as a function of the distance travelled by such vehicle.

From the foregoing description, it will be apparent to those skilled in the art that this invention provides a laser beam responsive signal-seeking, vertically adjustable mast which will automatically maintain a photocell unit on the mast in alignment with a laser beam. Other utilizations and modifications of this invention within the scope of the appended claims will be readily apparent to those skilled in the art.

I claim:

1. A vertically adjustable mast for mounting a laser beam detecting unit comprising:

1. a mounting base having a horizontal wall and a depending peripheral flange defining a power transmission chamber;

2. an upstanding cylindrical wall on said base;

3. a tubular housing anchored in said cylindrical wall;

4. a tubular mast slidably mounted in said housing, said mast having an internally threaded nut member rigidly mounted to the lower portion of said mast and concentrically disposed relative to the axis of said tubular mast;

5. an elongated screw engaging the threads of said nut member and having a lower shaft portion journalled in said horizontal wall and projecting into said power transmission chamber;

6. a reversible motor mounted on said horizontal wall and having a vertical driveshaft projecting downwardly into said transmission chamber;

7. speed reduction means interconnecting said motor shaft and said shaft portion of said screw, whereby said motor effects raising or lowering movements of said mast relative to said housing; and

8. limit switch means mounted on the end of said shaft portion of said elongated screw and operably connected to said reversible motor to de-energize same whenever said mast approaches its top or bottom limiting position.

2. The combination defined in claim **1,** plus an indicating shaft journalled in said base, and gear means for driving said indicating shaft in fixed ratio relationship with said elongated screw, whereby the rotation of said indicating shaft is a linear function of the height of said mast.

3. The combination defined in claim **1,** wherein said limit switch means comprises a horizontally disposed rod journalled in said transmission chamber's reduction gearing, means interconnecting said lower end of said elongated screw and said rod, said rod having its opposed ends threaded, a pair of internally threaded blocks mounted on said threaded ends of said rod, whereby rotation of said rod effects axial movements of said blocks, and a pair of limit switches respectively actuated by said blocks when said blocks respectively move to positions respectively corresponding to maximum extension or maximum contraction of said mast.

* * * * *