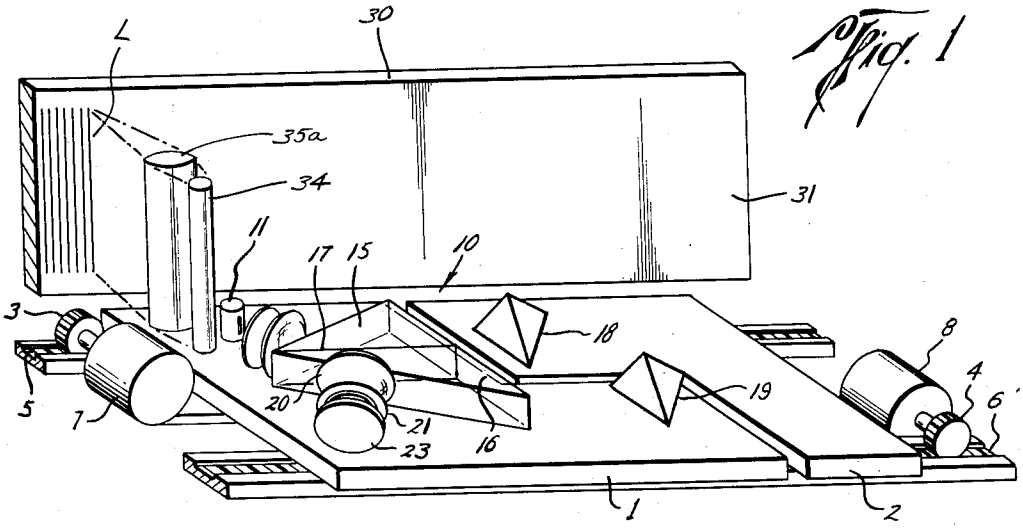
June 26, 1962 J. T. FERRIS 3,040,620

GRID RULING MACHINE

Filed June 2, 1958

Fig. 1



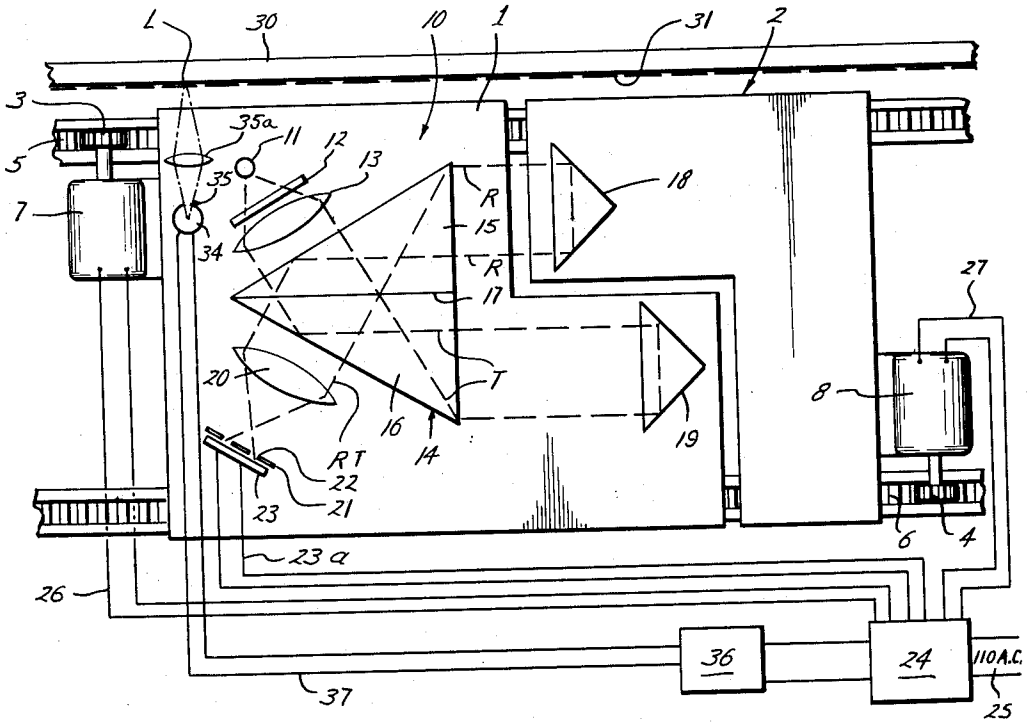


Fig. 2

John T. Ferris
INVENTOR.

BY Arnold & Stidham

ATTORNEYS

United States Patent Office 3,040,620 Patented June 26, 1962

3,040,620
GRID RULING MACHINE

John T. Ferris, Houston, Tex., assignor to Dresser Industries, Incorporated, Dallas, Tex., a corporation of Delaware

Filed June 2, 1958, Ser. No. 739,123
15 Claims. (Cl. 88—24)

This invention relates to grid ruling machine and, more particularly, to apparatus for effecting an accurate transverse ruling of a grid blank of extensive length.

In the past grids have been ruled by machines using conventional mechanical drives and stop and start controls in conjunction with a reciprocating mechanical scribing carriage. However, it is apparent that the numerous increments of short movement of the carriage interrupted by a complete stop during the operating stroke of the scribing carriage permits a repeated back lash or play between the machine elements within the limits of manufacturing tolerances. Since perfect accuracy in the design and construction of conventional machine elements is unattainable, even small errors in scribing are multiplied with repetition so that grids scribed by such machines are necessarily limited in length.

More recently interferometers have been employed to control the longitudinal increment of movement of the scribing carriages but since interference fringes lose their brilliance and contrast to an unusable level beyond certain minimum limits of movement, grids of more than a few centimeters in length cannot be produced under conventional interferometric control.

It is, therefore, an object of my invention to provide a machine capable of producing ruled grids of a length unlimited by the necessity of minimizing multiplication of machine errors, or by the limits of practical interferometric operation.

It is a further object of my invention to provide a means for ruling grids during continuous motion of the ruling device along the length of the grid blank.

It is a further object of my invention to provide an interferometer having an operating range limited only by the length of the machine ways along which it is guided.

It is a further object of my invention to provide a novel method of ruling a grid blank which does not require start and stop increments of movement of the supporting carriage.

It is a further object of my invention to provide a grid ruling machine that is automatic and, at the same time, reliable and accurate in operation.

In carrying out my invention, I provide a pair of carriages adapted to move along well machined ways. Drive means and stop means which may be integrated are provided for independent movement of each carrier. Elements of an interferometer are arranged on the carriages so that relatively movable elements thereof are separately movable. Control means are provided to move the carriages along the ways alternately, step by step, in increments within the practical range of the interferometer, with one carriage supporting a unique marking device that is operable during movement of that carriage. Thus, there is a setting stroke of one carriage, an active stroke of the marking carriage, a setting stroke and so on until the full length of the ways has been traversed if desired. For marking the grid blank, I provide a coating of light sensitive emulsion on the blank and employ as the marking device a source of light capable of exposing a fine line across the width of the grid blank. The source of

light is fired at intervals during continuous movement of the marking carriage in response to signals generated by the interferometer.

Other objects and advantages of my invention will become apparent from the description following when read in connection with the drawing wherein:

FIG. 1 is an isometric view of my apparatus; and

FIG. 2 is a schematic plan view of the ruling machine.

Referring now to the drawing, my grid ruling machine comprises two carriages **1** and **2** separately driven along well machined ways by any conventional drive means such as pinions **3** and **4**, engaging racks **5** and **6** along the machined ways. Each gear **3**, **4** is driven by an electric motor **7** and **8**, preferably of the servo type so that the velocity, starting and stopping of the carriages **1** and **2** along the ways, can be maintained under close control. As is well known, the desired velocity control is achieved with a servo motor by modifying the current delivered thereto in response to variations in speed actually delivered thereby. But in any event, the specific drive means employed for the carriages is not material and the motors and gears described are shown by way of illustration only. Other speed control mechanisms such as speed reducers can be utilized to supplement the means shown. Moreover, other mechanisms such as constant tension springs or even gravity may be substituted as drive means. The important consideration in the apparatus to be hereinafter described is that means be provided to start, stop and otherwise control with extreme accuracy the movements of the carriages **1** and **2**.

The extent of movement of the carriages **1** and **2** is closely controlled by an interferometer **10** mounted thereon. The interferometer includes a source of monochromatic light, such as a cadmium vapor discharge tube **11** coupled with a narrow band filter **12**. The near monochromatic light issuing from filter **12** is passed through a collimating lens **13** which directs a column of light into a dividing prism **14**, comprising two 30—60—90 degree prisms **15** and **16** cemented together. Significantly, at least one of the prisms **15**, **16** is aluminized at their union face **17** so that equal amounts of light will be reflected and transmitted by the plane of union, the reflected light being designated by the arrows R and the transmitted light by the arrows T. From the dividing prism **14** the reflected and transmitted light R and T pass into tetrahedral or corner prisms **18** and **19**, respectively, which characteristically reflect light back along a path parallel to its path of entry, even though the prism is displaced in any direction transverse to such path of entry.

After being reflected from their respective tetrahedral prisms **18**, **19**, the reflected and transmitted light R and T return to the dividing prism **14** where each is again divided by the plane of union **17**. Here we are concerned with the transmitted components of the originally reflected light R and the reflected components of the originally transmitted light T both issuing from prism **14** along the lines RT toward a lens **20** which controls the diameter of the column of light impinging upon a shield or mask **21** having an annular aperture **22** therethrough which permits only a ring of light coincidental therewith to pass and impinge upon a photoelectric cell **23** which converts pulses of light into electrical pulses.

It will be noted that all components of the interferometer **10** are mounted on one carriage **1** except only one of the reflectors or tetrahedral prisms **18** which is mounted on carriage **2** to move therewith. As is well known in interferometers, relative movement between the reflecting prisms **18** and **19** will vary progressively the phase rela-

tionship of the light reflected therefrom and reunited in its exit from dividing prism **14**. That is, a prism movement of one-half wave length will increase the distance traveled by the light over both the paths of incidence and reflection of one full wave length. Consequently, after a relative movement of one-half wave length, the originally reflected and transmitted light waves R and T will exit toward shield **21** in phase again. By the same token, a relative movement of one-fourth wave length will cause the reflected and transmitted light R and T to exit from prism **14** in interference, i.e. one-half wave length out of phase. Consequently, continuous movement through the maximum light of phase coincidence and the darkness of interference produces a successively light and dark fringe pattern which from the collimated light emitted from lens **13** is in the form of concentric rings moving outwardly from or inwardly toward the center, depending upon the direction of relative movement between reflecting prisms **18** and **19**.

As each ring of light in the fringe pattern produced assumes a diameter wherein it coincides with the annular aperture **22** of shield **21**, a pulse of light impinges upon the photo-electric cell **23** to be converted into a pulse of electricity fed by conductors **23***a* to an electronic counter and control circuit **24** for counting such pulses. Thus, relative movement between the reflecting prisms **18** and **19**, and hence carriages **1** and **2**, can be indicated by electrical pulses in increments of one-fourth wave length of the monochromatic light emitted from source **11**. Of particular significance is the capability of my apparatus to extend this indication or measurement of minute increments over a total travel of the carriages **1** and **2** limited only by the length of the ways **5** and **6**.

The electronic counter and control circuit **24** functions to control the speed of the carriages **1** and **2** and the operation of electrical switches in accordance with the receipt of given numbers of electrical pulses. Through such switches, a source of alternating current **25** may be varied and selectively connected through conductors **26** and **27** to motors **7** and **8**, respectively, driving carriages **1** and **2**. For example, when the carriages **1** and **2** are in the position shown, a signal produced by the counter and control circuit **24** will close an appropriate switch to direct current from the source **25** to the motor **8** for driving the leading carriage **2**. During this movement intermittent fringes impinge upon photo-electric cell **23** to produce electrical pulses to be counted by control circuit **24**. When a predetermined number of pulses have been counted, the circuit of motor **8** is opened to stop further movement of the carriage **2**. The number of pulses measuring this movement is determined by the effective range of the interferometer **10**. That is, the relative movement of this and, in fact, all interferometers must be within a range wherein the fringe pattern produced thereby is sufficiently sharp and brilliant to effect reliable functioning of the photo-electric cell **23**. Therefore, assuming that the reflecting prisms **18** and **19** as illustrated in FIG. 2 are within the usable range, the carriage **2** may be moved until prism **18** has moved from the left of prism **19** (in FIG. 2) to the same distance to the right thereof.

After the circuit of motor **8** has been opened, a delayed signal closes the circuit of motor **7** to move carriage **1** to the right in FIG. 2 and, hence, prism **19** first toward and then beyond prism **18** to the original position, shown in FIG. 2. Again, electrical pulses are fed to the counter and control circuit **24** until in response to appropriate signal the circuit of motor **7** is opened. Subsequently, motor **8** is energized and the cycle repeated. Therefore, it is apparent that the carriages **1** and **2** can be moved along over indefinite lengths in step by step stages measured in terms of one-fourth wave length of monochromatic light source **11**. Such apparatus is particularly adapted to produce elongate grids by a novel means.

Adjacent to the path traveled by the carriages **1** and **2** is secured an elongate grid blank **30** of metal, glass, plastic or the like. The grid blank **30** may be held stationary by any conventional fasteners, clamps or other holding means and disposed as shown with its longitudinal axis parallel to the ways **5** and **6** and its transverse axis perpendicular to the plane of the carriages **1** and **2**. On the adjacent surface of the grid blank **30** is a coating **31** of a light sensitive emulsion requiring the maintenance of controlled conditions of area illumination to avoid inadvertent exposure.

Mounted on carriage **1** to travel therewith is an elongate electronic flash tube **34** having its longitudinal axis disposed perpendicular to the plane of the carriage **1** and, hence, parallel to the surface of the grid blank **30**. The flash tube **34** has the surface thereof aluminized to prevent the transmission of light except through a narrow straight line slit **35** etched or scribed along the length thereof by accurate machine tool methods. Therefore, each time the tube is flashed, a narrow, vertical beam of light is transmitted to and through a lens **35***a* which focuses the beam to a narrow line of light impinging upon the light sensitive coating **31** to expose a fine line L transversely across the surface of grid blank **30**.

The flash tube **34** is energized upon closing of an appropriate switch in the control circuit **24** by the source of stored electrical power of a conventional power supply and trigger circuit **36** and conductors **37**. The control circuit is adapted to trigger the power supply each time a predetermined number of pulses are delivered by photo-electric cell **23** only during the movement of carriage **1**.

It is believed that the operation of my apparatus can now be readily understood. In response to appropriate signal the motor **8** is energized to move carriage **2** in advance of carriage **1** to set the grid ruling apparatus for operation. Throughout the movement of carriage **2**, the power supply **36** is inactive. Then, carriage **1** is driven by motor **7** through a distance measured by a predetermined number of pulses delivered by photo-electric cell **23**. Throughout this movement power supply **36** is operative and repeatedly on appropriate signal from control circuit **24** in response to a fixed number of pulses delivered thereto releases an electrical signal to energize the flash tube **34** and expose a narrow line on the face of grid blank **30**. After exposure the light sensitive emulsion is processed by conventional photographic techniques. In the case of extremely long grids the developing process can be performed with the grid still in position by manual application of developing chemicals.

Again, while I have referred specifically to a motor and gear and rack drive for the carriage, it is obvious that many different types of drive means may be employed. It is significant only that start and stop means for the carriage be under the control of mechanism operated in response to signals generated by the interferometer **10**.

While I have shown a preferred embodiment of my invention, it is apparent that many modifications and changes may be made therein without departing from the spirit and scope of my invention which is defined by the claims appended hereto.

Having described my invention, I claim:

1. Apparatus for ruling a grid blank comprising,
a grid marking device,
first and second carriages independently movable along a fixed path parallel to said grid blank,
said grid marking device being mounted upon said second carriage for movement relative to said grid blank, an interferometer including a pair of light reflectors, one of said reflectors being mounted on said first carriage, the other of said reflectors being mounted on said second carriage,
movement of said one reflector relative to said other reflector producing interference fringes of relative light and dark,

a transducer for converting such fringes of relative light and dark into electrical pulses upon relative movement between said first and said second carriages,

means for effecting movement of said first carriage along its said path over a predetermined distance and then terminating such movement,

activating means operative after completion of said first carriage movement for moving said second carriage, and means connected to said transducer for energizing periodically said grid marking device upon receipt of a predetermined number of electrical pulses during movement of said second carriage.

2. A grid ruling apparatus as defined in claim 1 including means for stopping movement of said second carriage, said stopping means being energized in response to a given number of electrical pulses.

3. Apparatus for ruling a grid blank comprising, first and second carriages movable along a fixed path parallel to said grid blank, an interferometer including a pair of light reflectors, movement of one of said reflectors relative to the other of said reflectors of said interferometer producing interference fringes, said one reflector being mounted on said first carriage and said other reflector being mounted on said second carriage, a transducer for converting light pulses into electrical pulses, a shield having an aperture therein concentric to said interference fringes to permit intermittent light pulses to impinge upon said transducer during relative movement of said first and second carriages, setting means for effecting movement of said first carriage, first carriage stopping means connected to said transducer and energized responsive to transmission of a given number of electrical pulses for preventing further movement of said first carriage, activating means operative after energization of said first carriage stopping means for effecting movement of said second carriage, a grid marking device, one of said grid marking devices and said grid blank being mounted on said second carriage, and means connected to said transducer for energizing periodically said grid marking device upon every receipt of predetermined number of electrical pulses during movement of said second carriage.

4. A grid ruling apparatus as defined in claim 3 including means connected to said transducer for stopping movement of said second carriage, said stopping means being energized in response to a given number of electrical pulses.

5. Apparatus for ruling a stationary grid blank having a light sensitive coating thereon comprising first and second carriages movable along a fixed path parallel to said grid blank, an interferometer including a pair of light reflectors, one of said reflectors being mounted on said first carriage and the other of said reflectors being mounted on said second carriage, movement of said one reflector relative to other reflector producing interference fringes, a transducer on said second carriage for converting light pulses into electrical pulses, a shield having an aperture therein concentric to said interference fringes to permit intermittent light pulses to impinge upon said transducer during relative movement of said first and second carriages, setting means for effecting movement of said first carriage, first carriage stopping means connected to said transducer and energized upon transmission of a given number of electrical pulses for preventing further movement of said first carriage, activating means operative after energization of said first carriage stopping means for effecting movement of said second carriage, a light source operative when energized to project a line of light on said light sensitive coating transverse to said fixed path, and means connected to said transducer for energizing said light source periodically in response to transmission by said transducer of predetermined ones of electrical pulses produced during movement of said second carriage.

6. A grid ruling apparatus as defined in claim 5 including means for stopping movement of said second carriage, said stopping means being energized in response to a given number of electrical pulses.

7. Apparatus for ruling an elongate stationary grid blank comprising, first and second carriages movable along a fixed path parallel to said fixed path, driving means for each of said first and second carriages, an interferometer including a pair of light reflectors, one of said reflectors being mounted on said first carriage and the other of said reflectors being mounted on said second carriage, movement of said one reflector relative to said other reflector producing interference fringes, a transducer on said second carriage for converting light pulses into electrical pulses, a shield having an aperture therein concentric to said interference fringes to permit intermittent light pulses to impinge upon said transducer during relative movement of said first and second carriages, energizing means for said first carriage driving means, signal means connected to said transducer and operative upon receiving a first given number of electrical pulses for de-energizing said first carriage driving means and then energizing said second carriage driving means, said signal means being further operative upon receiving a second given number of electrical pulses to de-energize said second carriage driving means and then to energize said first carriage driving means, a grid marking device on said second carriage, and power means actuated upon receiving predetermined ones of said second given number of electrical pulses to energize said grid marking device.

8. Apparatus for ruling an elongate stationary grid having a light sensitive coating thereon comprising, first and second carriages movable along a fixed path parallel to said fixed path, driving means for each of said first and second carriages, an interferometer including a pair of light reflectors, one of said reflectors being mounted on said first carriage and the other of said reflectors being mounted on said second carriage, movement of said one reflector relative to said other reflector producing interference fringes, a transducer on said second carriage for converting light pulses into electrical pulses, a shield having an aperture therein concentric to said interference fringes to permit intermittent light pulses to impinge upon said transducer during relative movement of said first and second carriages, means energizing said first carriage driving means, signal means connected to said transducer and operative upon receiving a first given number of electrical pulses for de-energizing said first carriage driving means and then energizing said second carriage driving means, said signal means being further operative upon receiving a second given number of electrical pulses to de-energize said second carriage driving means and then to energize said first carriage driving means, a light source operative when energized to direct a line of light on said grid blank and power means actuated upon receiving predetermined ones of said second given number of electrical pulses for energizing said light source.

9. Apparatus for ruling an elongate stationary grid blank comprising, first and second carriages movable along a fixed path parallel to said fixed path, driving means for each of said first and second carriages, a power source connectable to each of said driving means, an interferometer including a pair of light reflectors, one of said reflectors being mounted on said first carriage and the other of said reflectors being mounted on said second carriage, movement of said one reflector relative to said other reflector producing interference fringes, a transducer on said second carriage for converting light pulses into electrical pulses, a shield having an aperture therein concentric to said interference fringes to permit intermittent light pulses to impinge upon said transducer during relative movement of said first and second carriages, means connecting said source to said first car-

riage driving means, switch means connected to said transducer and operative upon receiving a first given number of pulses therefrom to disconnect said power source from said first carriage driving means and then to connect said power source to said second carriage driving means and operative upon receiving a second given number of pulses from said transducer to disconnect said power source from said second carriage driving means and then to connect said power source to said first carriage driving means, a grid marking device on said second carriage, and power means actuated upon receiving predetermined ones of said second given number of electrical pulses to energize said grid marking device.

10. Apparatus for ruling an elongate stationary grid blank comprising, first and second carriages movable along a fixed path parallel to said fixed path, driving means for each of said first and second carriages, a power source connectable to each of said driving means, an interferometer including a pair of light reflectors, movement of one of said reflectors relative to the other of said reflectors producing interference fringes, said one reflector being mounted on said first carriage and said other reflector being mounted on said second carriage, a transducer on said second carriage for converting light pulses into electrical pulses, a shield having an aperture therein concentric to said interference fringes to permit intermittent light pulses to impinge upon said transducer during relative movement of said first and second carriages, means connecting said source to said first carriage driving means, switch means connected to said transducer and operative upon receiving a first given number of pulses therefrom to disconnect said power source from said first carriage driving means and then to connect said power source to said second carriage driving means and operative upon receiving a second given number of pulses from said transducer to disconnect said power source from said second carriage driving means and then to connect said power source to said first carriage driving means, a light source on said second carriage operative when energized to direct a line of light on said grid blank and power means actuated upon receiving predetermined ones of said second given number of electrical pulses for energizing said light source.

11. Apparatus for producing controlled movement of a member comprising first and second carriages movable independently along a fixed path, said member being carried on one of said carriages, an interferometer including a pair of light reflectors, movement of one of said reflectors relative to the other of said reflectors producing interference fringes, said one reflector being mounted on said first carriage and said other reflector being mounted on said second carriage, a transducer for converting light pulses into electrical pulses, a shield having an aperture therein concentric to said interference fringes to permit intermittent light pulses to impinge upon said transducer during relative movement of said first and second carriages, setting means for effecting movement of said first carriage, first carriage stopping means connected to said transducer and energized upon transmission of a first given number of electrical pulses for preventing further movement of said first carriage, activating means operative after energization of said first carriage stopping means for effecting movement of said second carriage.

12. The apparatus defined in claim 11 including means connected to said transducer for stopping movement of said second carriage, stopping means being energized in response to a second given number of electrical pulses.

13. Apparatus for producing controlled movement of a member comprising first and second carriages movable independently along a fixed path, said member being carried on one of said carriages, driving means for each of said first and second carriages, an interferometer including a pair of light reflectors, movement of one of said reflectors relative to the other of said reflectors producing interference fringes, said one reflector being mounted on

said first carriage and said other reflector being mounted on said second carriage, a transducer on said second carriage for converting light pulses into electrical pulses, a shield having an aperture therein concentric to said interference fringes to permit intermittent light pulses to impinge upon said transducer during relative movement of said first and second carriages, means energizing said first carriage driving means, signal means connected to said transducer and operative upon receiving a first given number of electrical pulses for de-energizing said first carriage driving means and then energizing said second carriage driving means, said signal means being further operative upon receiving a second given number of electrical pulses to de-energize said second carriage driving means and then to energize said first carriage driving means.

14. Apparatus for producing controlled movement of a member comprising first and second carriages movable independently along a fixed path, said member being carried on one of said carriages, driving means for each of said first and second carriages, a power source connectable to each of said driving means, an interferometer including a pair of light reflectors, movement of one of said reflectors relative to the other of said reflectors producing interference fringes, said one reflector being mounted on said first carriage and said other reflector being mounted on said second carriage, a transducer on said second carriage for converting light pulses into electrical pulses, a shield having an aperture therein concentric to said interference fringes to permit intermittent light pulses to impinge upon said transducer during relative movement of said first and second carriages, means connecting said source to said first carriage driving means, switch means connected to said transducer and operative upon receiving a first given number of pulses therefrom to disconnect said power source from said first carriage driving means and then to connect said power source to said second carriage driving means and operative upon receiving a second given number of pulses from said transducer to disconnect said power source from said second carriage driving means and then to connect said power source to said first carriage driving means.

15. Apparatus for producing controlled movement of a member comprising

first and second carriages movable independently along a fixed path,

said member being carried on one of said carriages,

driving means for each of said first and second carriages,

an interferometer including a pair of light reflectors,

movement of one of said reflectors relative to the other of said reflectors producing interference fringes of relative light and dark,

said one reflector being mounted on said first carriage and said other reflector being mounted on said second carriage,

a transducer for converting such fringes of relative light and dark into electrical pulses upon relative movement between said first and second carriages,

means energizing said first carriage driving means,

signal means connected to said transducer and operative upon receiving a first given number of electrical pulses for de-energizing said first carriage driving means and then energizing said second carriage driving means,

said signal means being further operative upon receiving a second given number of electrical pulses to de-energize said second carriage driving means and then to energize said first carriage driving means.

References Cited in the file of this patent

UNITED STATES PATENTS

1,455,795 Logan ---------- May 22, 1923

(Other references on following page)

9

UNITED STATES PATENTS

1,744,642	Kondo	Jan. 21, 1930
1,814,701	Ives	July 14, 1931
2,123,276	Eckerlin	July 12, 1938
2,506,141	Drouin	May 2, 1950
2,527,338	Stamm	Oct. 24, 1950
2,575,367	Strong	Nov. 20, 1951
2,702,393	Merton	Feb. 22, 1955

10

FOREIGN PATENTS

745,919	Great Britain	Mar. 7, 1956

OTHER REFERENCES

Jenkins and White, "Fundamentals of Optics," second edition, 1950 McGraw-Hill Book Co., Inc., New York, N.Y., pages 247–249. (Copy in Div. 7.)