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OPTICAL COMMUNICATIONS TRANSMITTER

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Fig. 1.

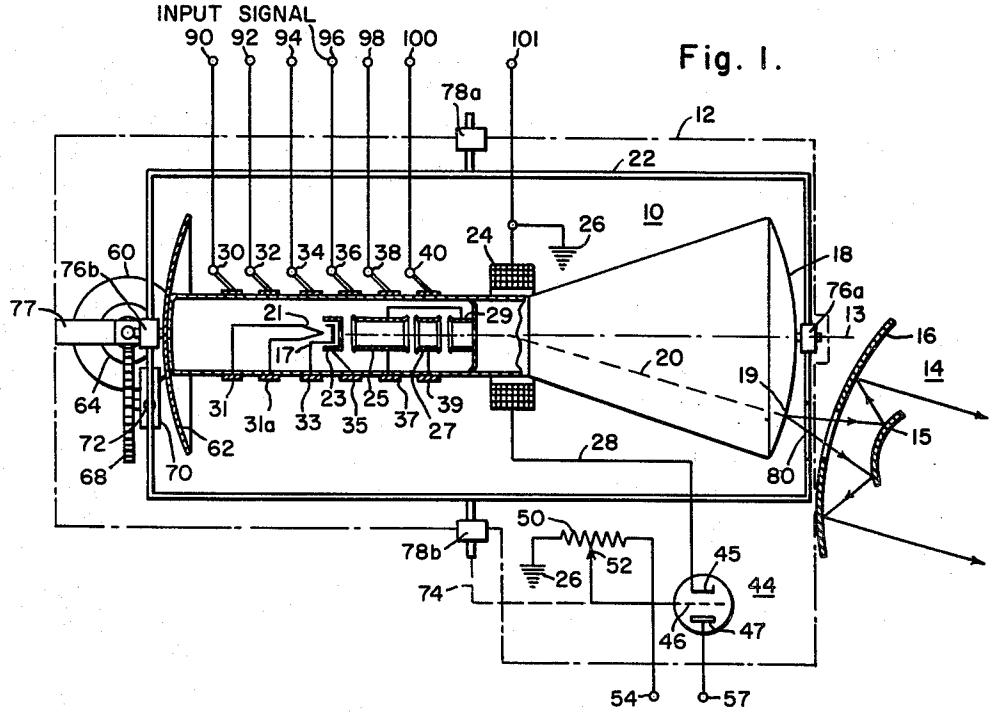
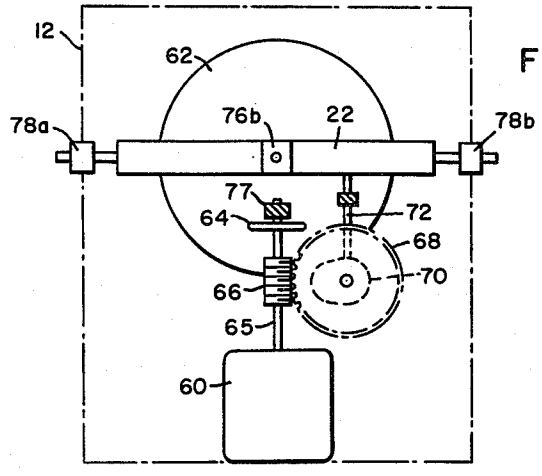


Fig. 2.



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OPTICAL COMMUNICATIONS TRANSMITTER

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This invention relates to communications apparatus and more specifically to a transmitter for a communication system which operates in the optical region of the electromagnetic spectrum.

A small concentrated luminous spot can be produced in conventional cathode ray tubes having an instantaneous brightness in the order of a million foot-lamberts but unless the electron beam producing the luminous spot can be moved around on the phosphor screen, it will burn the phosphor and even melt a hole in the glass envelope. Therefore, a rather high speed of movement depending upon the energy of the electron beam is required. Sweeping the beam over the screen such as in the form of a raster will provide an average area brightness equal to the instantaneous spot brightness provided by the ratio of raster area to spot area. By means of a stationary lens or mirror system this raster may be focused into a small spot of extremely high brightness, but such a system cannot retain the light energy within a narrow beam for direction to a distant point. Such direction of light energy to a distant point, for example outer space communication, requires the light energy to be emitted from a spot of the smallest dimensions possible i.e., a point source. One solution to this problem is to keep the electron gun and beam stationary and rotate the phosphor screen and have its axis of rotation moved back and forth whereby the beam sweeps over an annular ring on the phosphor and burning is thereby prevented. Even though the screen is moving, the gun is stationary and therefore the luminous spot is also stationary with respect to the environment. Such apparatus is described in U.S. patent application Serial No. 159,246, filed December 14, 1961 by R. J. Schneeberger which case is assigned to the assignee of the present invention. One difficulty which exists with the apparatus as described by R. J. Schneeberger is that the motor, bearings, and transilatory movement of the phosphor screen is operated either at the vacuum of outer space or either the high vacuum inside of an evacuated envelope. Outgassing of the motor e.g. decomposition and evaporation of insulation and breakdown of the lubrication for the bearings are particularly difficult problems which have not been overcome.

An object of the present invention, therefore, is to provide an improved optical transmitter for providing communications in the region of the electromagnetic spectrum including ultraviolet, visual and infrared radiation.

Another object of the present invention is to provide an optical transmitter which has a high intensity point source which can be intensity modulated at megacycle rates.

Still another object of the present invention is to provide an improved optical transmitter which is especially adaptable for emission of ultraviolet radiation and which can be used for communication between extreme distances, such as space vehicles.

Other objects and advantages will become apparent after a study of the following specification when read in conjunction with the accompanying drawings in which:

FIGURE 1 is an illustrative diagram of the preferred embodiment of the present invention; and,

FIG. 2 is a diagram further illustrating the preferred embodiment.

The present invention generates a high intensity source

of optical energy including ultraviolet, visual and infrared radiation by means of a cathode ray tube which produces a tiny sharply focused spot without overheating and destroying the phosphor while at the same time preventing outgassing of the motor and vaporization of the lubricants. This is accomplished by physically rotating the entire cathode ray tube about its longitudinal axis and not only the phosphor screen, while maintaining the electron beam deflection yoke stationary. This arrangement keeps the electron beam and hence the radiated light energy substantially fixed in space due to the external stationary magnetic field while the phosphor coated cathode ray tube face is continuously rotating and bringing cool phosphor areas under the beam excitation and spinning hot areas away for a cooling off period. For experimental purposes on the ground, the motor, bearings, and drive mechanism can be kept at ordinary atmospheric pressure. For applications under high vacuum conditions, such as outer space the entire system is kept in an envelope at a gas pressure which does not pose insurmountable lubrication problems.

Referring more particularly to FIG. 1, a cathode ray tube 10 is utilized which is essentially a conventional electrostatic focus, electromagnetic deflection cathode ray tube. Further the tube 10 is mounted in cradle 22 having bearings 76*a* and 76*b* located at both ends for allowing axial rotation of the tube about its longitudinal axis 13. The electron gun contained in the tube 10 comprising the filament 21, the cathode 17, the control grid 23, the accelerating electrode 25, first anode 27 and second anode 29, moreover is aligned with the bearings 76*a* and 76*b*. The deflection yoke 24 is held stationary. The cathode ray tube is rotated by means of a motor 60 and a rubber disc 64 connected to the motor shaft 65. The rubber disc 64 rests on a spherical disc 62 attached to the end surface at the neck of the cathode ray tube 10. The spherical disc 62, moreover, is connected to the bearing 76*b*. Rotation of the motor shaft 65 causes the rubber disc 64 to turn which drives the spherical disc 62 rotating the cathode ray tube 10.

An electron beam 20 is produced in the cathode ray tube 10 whose gun electrodes are connected to slip rings on the outside of the tube neck as follows: the filament 21 is connected to rings 31 and 31*a*; the cathode 17 is connected to ring 33, the control grid 23 is connected to ring 35, the accelerating anode 25 which is internally connected to the second anode 29 is connected to ring 37, and the first anode 27 is connected to ring 39. External power supply voltages, from a source not shown, are supplied to external terminals 90, 92, 94, 98 and 100 for operating the filaments, cathode and accelerating electrode and second anode, the first anode, respectively. Terminal 101 provides an external connection to a point of common reference potential 26. The voltages thus applied to the external terminals are applied to the respective tube elements by means of the contacts 30, 32, 34, 38, and 40 which ride on slip rings 31, 31*a*, 33, 37 and 39, respectively.

A luminous spot 19 is produced on the fluorescent screen 18 by means of the electron beam 20. By applying input signal to the input terminal 96 which is in turn connected to the control grid 23 by means of the slip ring 35 through contact 36, the intensity of the electron beam 20 is modulated to produce a light source at the luminous spot 19 varying in brightness corresponding to the input signal applied thereto.

By keeping the deflection yoke 24 stationary, a deflection voltage is applied to terminal 57 for maintaining the position of the electron beam 20 and consequently the spot 19 substantially stationary with respect to its environment which is moving. An electron tube 44 is utilized in the deflection circuit to control the amount of current

flowing in the yoke 24. This is accomplished by connecting one end of the yoke 24 to the cathode 45 of the electron tube 44 and by connecting the other end to a point of common reference potential 26. In addition, bearings 78*a* and 78*b* located in cradle 22 permit tilting of the tube axis 13 and consequently the cathode ray tube 10 itself. A potentiometer 50 having one side connected to a negative bias source, not shown, by means of terminal 54 and having the other side connected to a point of common reference potential 26 controls the deflection current by varying the negative bias voltage applied to the grid 46 thus varying the plate current flowing in the electron tube 44. In addition, bearings 78*a* and 78*b* located in the cradle 22 permit tilting of the tube axis 13 and consequently the cathode ray tube 10 itself. The potentiometer 50 is mechanically linked by means of its slider 52 through the mechanical linkage 74 to the bearing 78*b* such that the deflection current is made to vary inversely proportional to the tilt angle of the cathode ray tube 10. As observed from the outside of the cathode ray tube 10, the luminous spot 19 remains stationary even when the tube axis 13 is tilted.

By applying a slowly rocking motion the deflection current causes concentric circles of different diameters or a spiral of predetermined pitch to be written on the phosphor of the fluorescent screen 18 thereby increasing the utilized phosphor area. Referring to FIG. 2, this rocking motion is provided by means of the combination of a worm gear 66, circular gear 68, cam 70 and a connecting rod 72 connected to the cradle 22. The worm gear 66 is located on the shaft 65 of the motor 60, turning the cam 70 providing an upward and downward movement of the connecting rod 72 and the cradle 22.

In the present invention shown in FIG. 1, the cathode ray tube 10 is rotated by means of the stationary motor 60 and the rubber disc 64 in contact with the spherical disc 62. With a configuration thus provided, the speed of rotation of the cathode ray tube varies in accordance with the tilt angle provided by the rocking motion previously described. This is provided so that the writing speed on the phosphor and its heating can be maintained constant.

The phosphor used in the fluorescent screen 18 must have a relatively short persistence time that is, the time interval wherein brightness level drops to 1/10 of its peak value after excitation is removed must be very short. This is necessary in order to apply input signals varying at megacycle rates. One example is the commercially available P16 phosphor whose brightness level drops to 1/10 of its peak value within 2/10 of a microsecond after excitation is removed. When operating in the ultraviolet region of the electromagnetic spectrum for which the present invention is particularly suitable, the P16 has an even shorter persistence time for the ultraviolet light it radiates simultaneously with the visible light. Also acceptable for ultraviolet application is the P15 phosphor. Other available phosphors have even shorter persistent times. No phosphors are presently known which emit optical energy in the range, that is called far ultraviolet. Until now there has not been any practical use for such radiation because it is quickly absorbed in the atmosphere. However, such wavelengths are very suitable for space communication over long distances and would enhance the present invention when and if such phosphors become available.

Bearings and sliding contacts are positioned outside the vacuum envelope of the cathode ray tube 10. Lubricants are available which are satisfactory at low vacuum, but none seem to work effectively at very high vacuums. For operation in ground based airborne equipment or in the laboratory these parts operate under familiar environmental conditions. However, when operated in environments such as outer space, the entire apparatus is mounted in a sealed envelope 12 as shown in FIGS. 1 and 2, containing a gas under pressure sufficient to eliminate lubrication problems. A small window 80 is provided in the sealed envelope 12 near the position of the luminous spot 19. The light radiation emanating from the spot 19 is collected by the optical system 14 comprising a cassegrainian lens such that light is first reflected from reflector 15 and then by reflector 16 forming the light in a narrow beam for direction to a distanct point. By providing the sealed envelope 12 around the cathode ray tube 10 and its associated apparatus the light energy must traverse a short distance from the fluorescent screen 18 to the window 80 in a gas medium. When the subject invention is operated in the ultraviolet region of the optical spectrum a slight absorption is suffered in this gas passage. This loss, however, is minute since the distance can be made very short and the gas pressure very low.

As already noted the present invention is particularly adaptable for use in the ultraviolet region of the electromagnetic spectrum which offers several attractive features for space communications that the radio portion of the spectrum lacks. Because the beam width of radiated energy is proportional to frequency, ultraviolet provides vastly increased energy concentration. This means that longer communication ranges can be obtained with far less power and with much smaller antennas and collectors than at radio frequency. Both are important considerations for space vehicles where electric power is at a premium and large antenna structures pose weight and mechanical design problems. The narrow beam width which can be a tiny fraction of a degree using modest size optics, such as shown in FIG. 1, offers attractive advantage particularly for military use, these being communications privacy and comparative security for man made and certain types of natural interference.

In the preferred embodiment of FIG. 1 the cathode ray tube voltages are supplied by means of slip rings on the tube neck. If desired, a conventional tube base may be utilized and the slip rings provided on the tube socket. Also instead of having bearings at both ends of the cathode ray tube it may be supported by its neck in suitable bearings such as rollers or discs positioned around the tube neck. In addition, electrostatic focus means have been shown but electromagnetic focus coil may likewise be utilized outside of the tube instead of the electrostatic focusing.

In summation therefore, the present invention provides an improved means for generating a high intensity point source of radiation for use in optical communications systems. Whereas previous devices would experience lubrication problems and decomposition due to the vacuum environment when operated in outer space the subject invention provides a means in which an optical transmitter can be efficiently operated either in the environment of earth or in outer space without experiencing detrimental outgassing and lubrication difficulties.

Accordingly, while there has been shown and described what is at present considered to be the preferred embodiment of the present invention, modifications thereto will readily occur to those skilled in the art. It is not desired, therefore, that the invention be limited to the specific arrangements shown and described. It should be understood that changes may be made and equivalents substituted without departing from the spirit and scope of the invention.

I claim as my invention:

1. A transmitter for optical communications comprising in combination: a cathode ray tube having a longitudinal axis and including a fluorescent screen; means operably connected to said cathode ray tube for producing a point source of light at a predetermined spot on said fluorescent screen; means operable with said cathode ray tube for maintaining the position of said point source substantially stationary in space; means connected to said cathode ray tube for simultaneously axially rotating and tilting said cathode ray tube about said longitudinal axis; and means located adjacent said

point source for directing the light emanating therefrom to an external location.

2. A transmitter for optical communications comprising in combination: a cathode ray tube having a longitudinal axis and including a fluorescent screen; means operably connected to said cathode ray tube for producing a point source of light at a predetermined spot on said fluorescent screen; an input means; means connected to said input means for varying the intensity of said point source in accordance with an input signal; means operable with said cathode ray tube for maintaining the position of said point source substantially stationary in space; means connected to said cathode ray tube for simultaneously axially rotating and tilting said cathode ray tube about said longitudinal axis; and means located adjacent said point source for directing the light emanating from said point source to an external point.

3. A transmitter for optical communications comprising in combination: a cathode ray tube having a longitudinal axis and including a fluorescent screen; means operably connected to said cathode ray tube for generating a sharply focused point source of light energy including the ultraviolet, the visual, and the infrared regions of the electromagnetic spectrum, at a predetermined location on said fluorescent screen; deflection means operable with said cathode ray tube for maintaining the position of said point source substantially stationary with respect to said fluorescent screen; means connected to said cathode ray for simultaneously axially rotating and tilting said cathode ray tube about said longitudinal axis; and optical means located adjacent said point source for beaming said light energy emitted therefrom to an external station.

4. A transmitter for optical communications comprising in combination: a cathode ray tube having a longitudinal axis and including a fluorescent screen; means operably connected to said cathode ray tube for producing a spot of light of a predetermined diameter at a predetermined point on said fluorescent screen; an input means; means operably connected to said input means for intensity modulating said spot of light; means operable with said cathode ray tube for deflecting said spot to a substantially stationary position with respect to an external observer; means connected to said cathode ray tube for simultaneously axially rotating and tilting said cathode ray tube about said longitudinal axis; and enclosure means including a gas under a predetermined pressure enveloping said cathode ray tube, said means for deflecting said spot, and said means for simultaneously axially rotating and tilting said cathode ray tube for providing a gaseous environment for operation in outer space; and optical means located adjacent said enclosure means for directing light emitted from said spot in a relatively narrow beam to a distant point.

5. A transmitter for optical communications in outer space comprising in combination: a cathode ray tube having a longitudinal axis and including a fluorescent screen; means operably connected to said cathode ray tube for producing substantially a point source of light at a predetermined location on said fluorescent screen, means operable with said cathode ray tube for maintaining the position of said point source substantially stationary in space; means connected to said cathode ray tube for simultaneously providing axial rotation and tilting of said cathode tube about said longitudinal axis in order to dissipate heat produced at said point source; envelope means containing a gas of a predetermined pressure disposed around said combination for providing an atmosphere of predetermined content for outer space operation, said envelope means also including a window for external transmission of said light emitted from said point source; and optical means located adjacent said window for receiving and beaming said light to a distant point in a relatively narrow beam.

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