

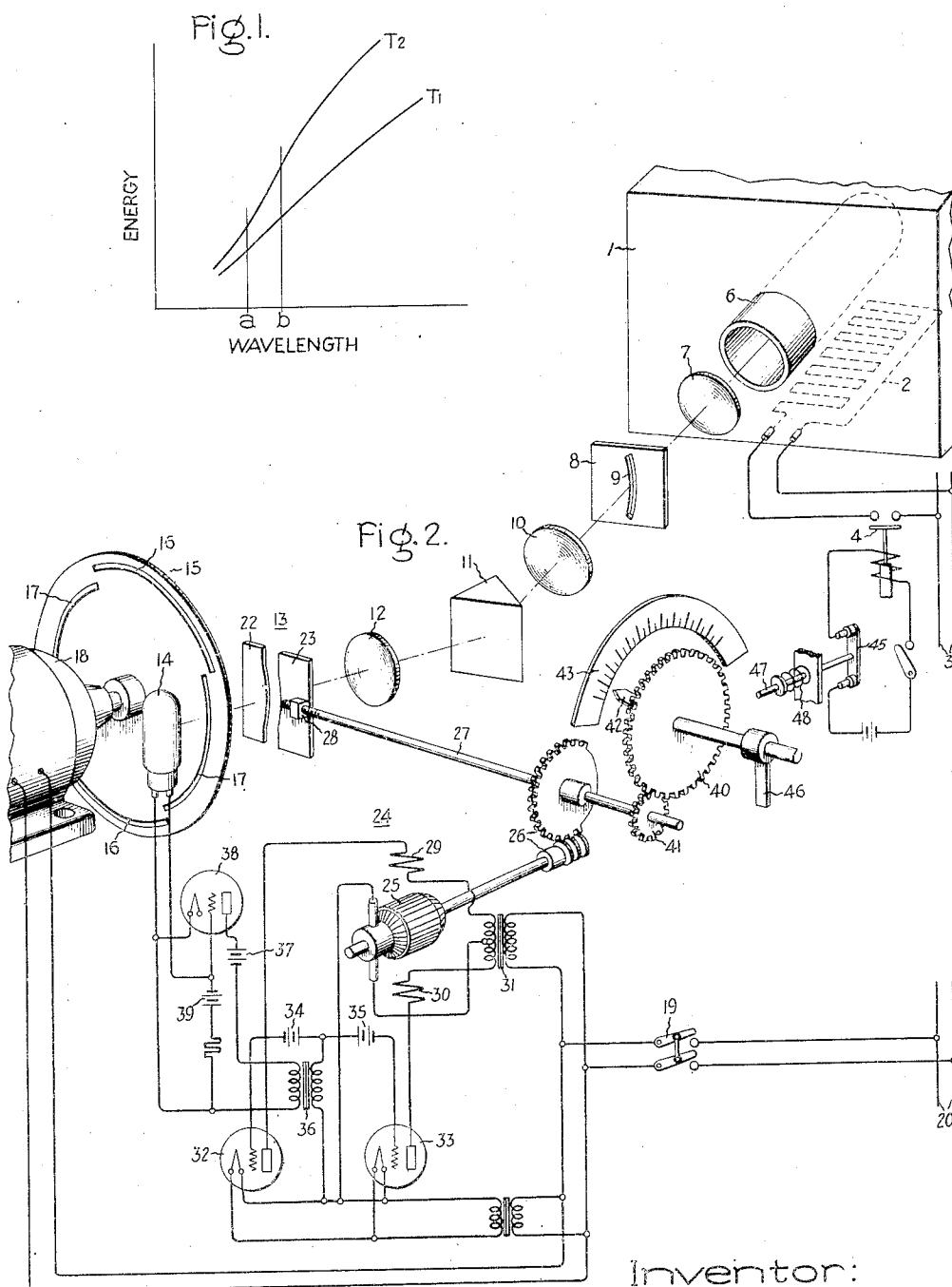
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L. R. RUNALDUE

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HIGH TEMPERATURE PYROMETER

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HIGH TEMPERATURE PYROMETER

Lewis R. Runaldue, Pittsfield, Mass., assignor to
General Electric Company, a corporation of
New York

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My invention relates to high temperature pyrometers and particularly to pyrometers which operate in response to radiant energy which under circumstances associated with its production must pass through an appreciable amount of smoke or dust before reaching the sensitive element of the pyrometer. Radiation responsive pyrometers of the various forms heretofore constructed have been found to be unreliable whenever the radiation passes through any appreciable amount of smoke or dust since this absorbs a certain amount of the radiation and accordingly introduces an error in the temperature indication. It is an object of my invention to provide an improved pyrometer whose operation shall be unaffected by the presence of smoke or dust in the path of the received radiation. Another object of my invention is the provision of such a pyrometer for use in connection with a furnace which is shown having means for the automatic control of the furnace temperature.

My invention is based upon the fact that the curve representing the spectral distribution of energy radiated by a hot body, namely, a curve whose ordinates represent the radiant energy of the body at a certain temperature and whose abscissa represent wave lengths of the energy, changes with variations in the temperature of the body. For a given temperature the amount of radiant energy on a certain wavelength, measured by the length of the ordinate for that wavelength will bear a certain relation to the amount of energy on a different wavelength, measured by the length of the corresponding ordinate. At a different temperature the curve has a different shape; hence the two amounts of energy at said wavelengths bear a different relation to each other. My invention makes use of this change in relation due to a change in the temperature. In this way I am able to avoid an incorrect response of the apparatus due to smoke or dust, for although smoke and dust absorb radiation more in some wavelengths than in others the absorption is selective; that is, the absorption is confined to narrow bands. In practicing my invention I avoid the use of the particular wavelengths which correspond to those narrow bands. My invention will be better understood from the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring to the drawing, Fig. 1 shows the spectral energy distribution curves for two temperatures T_1 and T_2 respectively and Fig. 2 is a combined diagrammatic view and circuit dia-

gram illustrating a preferred embodiment of my invention.

In Fig. 1 I have shown by the curves T_1 and T_2 the spectral distribution of energy for those temperatures the curves being plotted between energy and wavelength. The ordinates a and b represent two selected ordinates at wavelengths at which the radiation is absorbed by smoke and dust to a relatively slight degree only. It will be seen that the lengths of the ordinates a and b to the curve T_1 bear a certain ratio to each other; likewise the ordinates a and b to the curve T_2 bear a certain ratio to each other but the second ratio is different from the first ratio. It is this change in ratio of the ordinates a and b for the two selected wavelengths which is the basis of operation of the apparatus which I have devised and will now describe for measuring and controlling the temperature of the body producing the radiation.

In Fig. 2, 1 represents a furnace which is provided with an electrical heater 2 which is supplied from the source 3 through the control switch 4. Extending through the furnace coil is the protection tube 6 the inner end of which is closed and which is arranged to be heated to the temperature of the interior of the furnace. This closed end of the tube 6 therefore becomes the source of the radiation which is received by the energy responsive device of the apparatus.

Arranged in front of the tube 6 is the optical system now to be described by which the radiation is directed on the energy sensitive device. This system comprises the lens 7 which focuses the received energy onto the diaphragm 8 which is provided with an arcuate slot 9 having a curvature bearing a relation to the curvature of the openings in the rotating shutter to be described later. The energy which passes the slot 9 is refracted by the lens 10 so that it extends in substantially parallel rays to the prism 11. This prism is arranged to produce a spectrum and beyond the prism is the lens 12 which focuses the various monochromatic images of the slot on the two part diaphragm 13. Beyond the diaphragm 13 is the photo-electric device 14, such for example as a photo-electric tube, which is sensitive to the two selected wavelengths a and b . Arranged to rotate between the diaphragm 13 and photo device 14 is the disk shutter 15 which in the form illustrated has four arcuate openings substantially 90° in length two of which openings, namely, openings 16, being arranged nearer to the periphery than the other two opposite openings 17. The openings 16 are positioned so

as to pass radiation having a wavelength corresponding to the ordinate *b* while the openings 17 are positioned so as to pass radiation having a wavelength corresponding to the ordinate *a*.

5 While I have referred to ordinates *a* and *b* as being of a single wavelength, it is to be understood that in reality the openings 16 and 17 pass narrow bands of wavelengths which lie at the ordinates *a* and *b*. The shutter disk 15 is

10 mounted on the shaft of the synchronous motor 18 which is supplied through the switch 19 from the source 20 of alternating current, which for example, may be a 110 volt, 60 cycle house lighting circuit. Inasmuch as the shutter disk 15 has

15 four light openings the motor is constructed to rotate at thirty revolutions per second; each of the four openings in the disk being effective to pass radiation to the photo device during one half cycle of the alternating current supply.

20 The diaphragm 13 comprises the fixed part 22 and the movable part 23. When the two parts are separated at the maximum distance energy of the two wavelengths corresponding to ordinates *a* and *b* passes unobstructed between the

25 two parts to the disk 15. When, however, the movable part 23 is adjusted toward the fixed part 22, it serves to cut off and hence reduce the amount of radiation corresponding to wavelength of ordinate *b*. By means of the movable

30 part 23, therefore, I am able to vary the width of the wavelength band *b* and therefore the amount of energy in that band which reaches the photo tube. Part 23 is shifted toward or away from

35 part 22 by means of the reversible motor 24, the armature 25 of which motor connects through the worm gearing 26 with the shaft 27 which in turn is screw threaded into the nut 28 secured to the part 23. Motor 24 is provided with field

40 windings 29 and 30 which are supplied from the source of alternating current 20 through the transformer 31 under the control of the electron discharge tubes 32 and 33. The grids of the devices 32 and 33 are normally biased to cut off

45 by the batteries 34 and 35 and connected in a common part of the grid cathode circuits of these devices is the secondary of the transformer 36. The primary of this transformer is connected through the battery 37 with the anode of the electron discharge device 38. The grid of the

50 latter device is negatively biased by the battery 39 and is connected to be controlled by the photo-electric device 14 whereby when the device 14 is exposed to radiation the device 38 passes current. Variation in the amount of light striking upon

55 device 14 will cause a variation in the current through transformer 36. An alternating voltage is therefore induced in the secondary winding of 36.

With this arrangement if the diaphragm 13 happens to be so adjusted that equal amounts of radiation corresponding to the ordinates *a* and *b* reach the photo device then no voltage is induced in the secondary of 36, both 32 and 33 remain negatively biased and do not conduct. The

60 motor 24 is not energized and no movement of the part 23 takes place. If, however, the opening between the parts 22 and 23 is too wide, that is, radiation corresponding to the ordinate *b* is greater than that corresponding to the ordinate *a*, the phase relation of the voltage induced in

70 36 will be such that device 32 conducts energizing 29 and 25 and the motor will be rotated in a direction to close the opening between the parts 22 and 23 until equal amounts of radiation are

75 received by the photo tube. Likewise, if the

opening is too small, the motor will be operated in the opposite direction to move the part 23 in a direction to increase the opening by the operation of 33, 30 and 25. The position of the part 23 relative to the fixed part 22 is a measure or an

5 indication of the ratio of the amounts of energy received by the photo device at the two wavelengths corresponding to ordinates *a* and *b*. Since the movement of the part 23 is very small and difficult to measure directly, I have provided

10 the gear 40 meshing with the pinion 41 on shaft 27 and attached to gear 40 the pointer 42 which cooperates with the scale 43. This scale, if desired, may be calibrated to read directly in terms of temperature. I have also provided means for

15 automatically opening the circuit of the furnace heater 2 when the temperature therein reaches a predetermined point. This means comprises the limit switch 45 which controls the winding of the switch 4 in the heater circuit and the dog 46

20 on the shaft of the gear 40 which when the predetermined temperature is reached will engage the rod 47 and open the limit switch. When the temperature in the furnace again falls to a lower

25 value the dog 46 will disengage the rod 47 and the spring 48 will again close the limit switch.

While I have shown my invention as applied to the measurement and control of the temperature in an electric furnace, it is not confined to such uses but may be applied to the measurement of the temperature of various other hot

30 bodies, such for example as the temperature of hot ingots as they travel past the apparatus on a conveyor. One of the important advantages of this apparatus in addition to its being unaffected by smoke and dust is the fact that it does not require focusing on the hot body, that is, it operates independently of its distance from the

35 hot body. This advantage is of particular importance when it is used to measure the temperature of hot bodies travelling on a conveyor such as hot ingots where all the bodies are not at a uniform distance from the apparatus.

Another advantage of my invention is that the device will have the same calibration for radiating bodies under gray body conditions as under

45 black body conditions. This advantage will be appreciated the more when it is remembered that most radiating bodies are gray body radiators and that in the past it has been necessary

50 to apply corrections to all previous pyrometers of the optical or radiation class.

In certain cases I may find it desirable to employ filters to obtain the two bands of radiation corresponding to the ordinates *a* and *b* instead of

55 by the use of a prism as described above. Because of the difficulty, however, of obtaining filters which are effective to pass sufficiently narrow bands of the desired wavelength I prefer to employ a prism as described above.

I have chosen the particular embodiment described above as illustrative of my invention and it will be apparent that various modifications may be made without departing from the spirit and scope of my invention which modifications

60 I aim to cover by the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A high temperature pyrometer comprising a device responsive to radiant energy, means for segregating two separate wavelengths of received energy from the total wavelengths thereof and for applying them separately to said device and means responsive to said device for varying the relative amounts of energy of said segregated

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wavelengths applied to said device whereby said device makes the same response when subjected to either of said segregated wavelengths.

2. A high temperature pyrometer comprising
5 an energy responsive device, means for segregating the energy received on each of two wavelengths from the energy received on the other wavelengths and for passing the energies of said two wavelengths alternately to said device and
10 means controlled by said device by which the relative amounts of the energies of said two wavelengths may be varied until said device produces a like response to the energies of both wavelengths.

15 3. A high temperature pyrometer comprising means for segregating the energy received on each of two wavelengths from the energy received on the other wavelengths, an energy responsive device arranged to receive said two wavelengths,

means for alternately interrupting the energy of said two wavelengths, and means responsive to said device for varying the amount of energy received on one of said two wavelengths with respect to that received on the other.

4. A high temperature pyrometer comprising
5 a prism arranged to produce a spectrum of received radiant energy, a rotatable shutter having a plurality of narrow arcuate openings therein arranged alternately to pass portions of said
10 spectrum limited to two spaced wavelengths, a photo-electric device positioned to receive the wavelengths passed by said openings, a second shutter for varying the radiation passed by one of said openings and means responsive to a difference in output of said device due to the operation of said first shutter for moving said second
15 shutter.

LEWIS R. RUNALDUE.