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RADIANT ENERGY HIGH-TEMPERATURE HEATING APPARATUS

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Fig. 1.

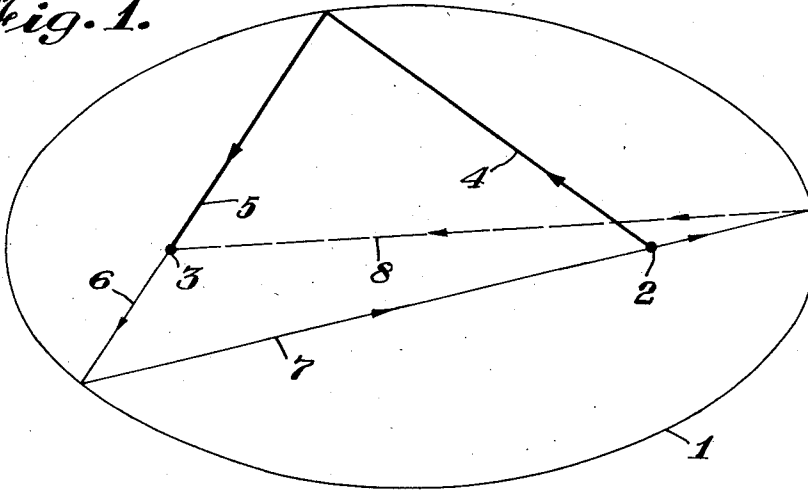
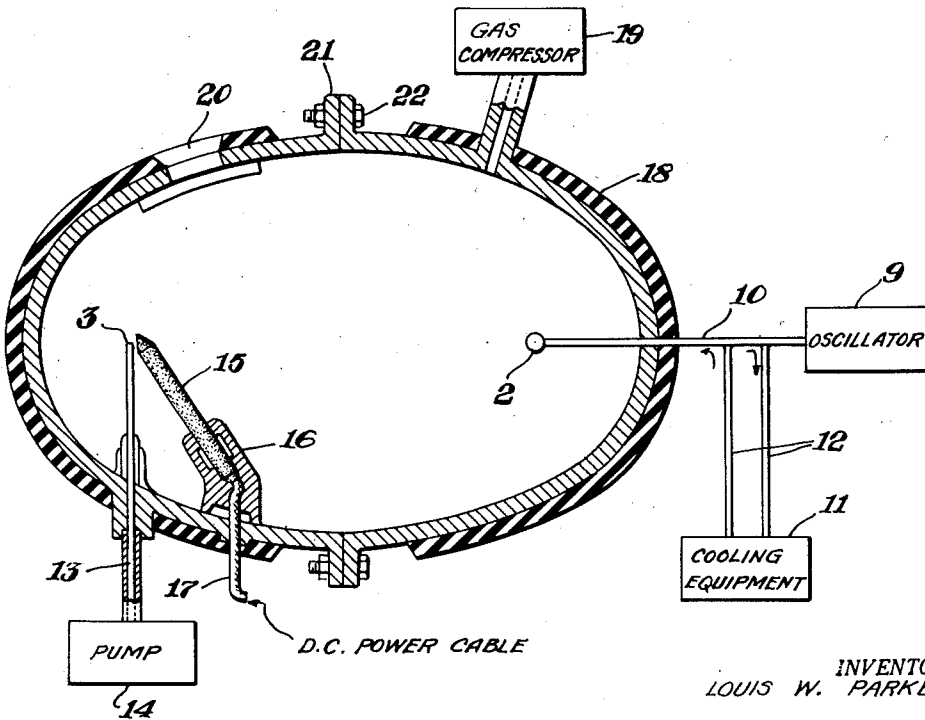


Fig. 2.



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RADIANT ENERGY HIGH-TEMPERATURE
HEATING APPARATUS

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8 Claims. (Cl. 219-47)

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This invention relates to radio-frequency heat generators, and more particularly to apparatus for concentrating radiant energy in a small space in order to subject a mass of material to extremes of heat.

Briefly, the invention comprises a small radio-antenna mounted at one focus of an ellipsoidal vessel, the object to be heated being located at the other focus. The vessel is metallic, so as to produce reflections at high efficiency and to focus the reflected energy at the point of utilization.

It is an object of my invention to provide apparatus for radiant energy heating which will be useful as a new tool for research.

Another object is to provide a container for a gas to be heated by radiant energy and to provide means for holding the container in a solid state notwithstanding the extremely high temperatures to which the gas is heated.

Still another object is to provide means for dissipating radio-frequency energy through a gaseous medium in which a flow of free electrons is produced by an externally fed arc discharge. Other objects and advantages of my invention may be inferred from the more detailed description to follow. This description is accompanied by a drawing in which:

Fig. 1 is a diagrammatic representation of radiant energy reflections within an ellipsoidal container, and

Fig. 2 shows a preferred embodiment of apparatus for carrying out the invention, the ellipsoidal container being sectioned and other related apparatus units being indicated by blocks because of their well-known structure.

According to well-known geometrical laws it will be understood that any radiation originating at one focus of an ellipsoid will be transferred to the other focus by reflection from the walls.

In Figs. 1 and 2 the vessel 1 is shown to be of ellipsoidal shape. An antenna which may be of dipole type is located at one focus 2 while the object to be heated is located at the other focus 3. A ray of energy such as 4 would be reflected as a ray 5. Ray 5 if not completely absorbed by the object at focus 3 would be directed along the line 6 and upon being again reflected would follow the course 7 back to the focus 2. If this course were extended still further, another reflection would result in the residue of the energy being directed along the line 8 which is aimed at the focus 3 where an object is to be heated. So, irrespective of the direction which any ray of energy takes upon leaving the antenna, it will always be reflected by the inner surface of the

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ellipsoid toward the other focus 3 where the object is positioned.

By making the sum of the distances of the rays 4 and 5 equal to a whole number of multiples of half wavelength, standing waves may be set up. At each reflection, therefore, the waves are combined additively in phase instead of at random phase as would otherwise be the case.

The antenna at focus 2 may be fed with microwave energy as generated by an oscillator 9. The energy is conducted into the vessel 1 by means of a transmission line 10. Suitable well known means may be provided for cooling the transmission line. This is conventionally indicated by the rectangle 11, labeled "Cooling Equipment," and pipes 12 may be used to carry a cooling fluid to and from the transmission line.

According to one mode of operation the substance to be heat-treated may be in a semi-liquid, or plastic state and may be pumped into the vessel through a pipe 13 which leads to the focus 3. The pump 14 is shown diagrammatically.

In order to provide an ionized gas in which to immerse the substance to be heated, and also for supplementing the radio-frequency heating source by other heating means, I may mount two carbon rods 15 across which an arc plasma discharge or positive column may be maintained at the focus 3. Because of the section plane of Fig. 2 only one of the rods 15 is shown. The resulting arc, the middle of which is coincident with the working focus, serves to vaporize and ionize the material to be heated. The radio frequency power at this focus is used to further raise the temperature of the ionized gases in the arc. The rods may be held in sockets 16 and may be fed with direct current through cables 17 connected to any suitable source. The vessel may be jacketed with any suitable layer of heat-insulating material 18.

Under certain circumstances it may be important to treat the substance in an atmosphere of compressed gas. With this purpose in view a compressor 19 is provided. Its output is piped into the vessel in any suitable manner. A window 20 is provided for viewing the operations inside the vessel. The window may be composed of quartz, if desired, in order to withstand the heat. It is securely set in place, forming a hermetic seal. The vessel may be made in two pieces and bolted together at their abutting flanges 21 by means of bolts 22. This arrangement, of course, facilitates replacement of the carbon electrodes for the arc discharge and of the material to be

treated, or the removal of the same after treatment.

That it is possible to generate heat and to concentrate the same in a small zone at extremely high temperatures by the use of my invention may be better understood from the following brief discussion of the theory of operation.

Heating of the gases resulting for the vaporization and ionization of the material disposed at the center of the arc, which are ionized in the plasma, or positive column, of an arc discharge results from the absorption of electromagnetic waves, particularly of very high frequency.

The energy of the waves so absorbed is changed to heat and light. While waves of any length are absorbed to a degree by the gases, there is a great difference in the absorption coefficient of any gas for various wavelengths. This is the well known phenomenon of selective absorption, where a number of narrow bands of frequencies find the gas almost entirely "black." Different elements are selective for different frequencies. Much of the wavelength region the invention contemplates using is unexplored, but in the opinion of experts a very pronounced selective absorption will take place in this range except that as the wavelength increases, the absorption coefficient drops. There are known mathematical formulas with which these various wavelength ranges can be determined, making it possible to design the oscillator for the wave length necessary to heat any desired element.

One example of the absorption of short radio waves by ionized gases can be found in the June 1934 issue of the IRE proceedings, under the title "Ionized gas modulators" by Linder and Wolff. These writers describe a way of absorbing 10 cm. waves by a gas in varying amounts by varying the degree of ionization. Their measurements showed that most of the energy in a concentrated beam of 10 centimeter waves is absorbed when passing thru a thickness of 20 cm. of ionized gas. The above mentioned selective absorption was not made use of in this experiment. It was found that the amount of energy reflected and refracted was small in comparison to the absorbed part.

One phenomenon that will be noticed when the apparatus shown in Fig. 2 functions is the strong convection currents set up by the difference of temperature in different parts of the gas. Too strong convection may blow out the arc. Also it may not permit the gas to remain long enough in the working focus to reach the highest temperature the apparatus is capable of imparting to it. These effects are reduced by using R. F. pulses instead of a sine wave, since convection currents are caused by the average rather than instantaneous heat. It was found by calculation that 160 kilowatts of pulses can raise the temperature of the gas in the working focus from 3000° Kelvin to 6000° Kelvin in less than 1/100 second. This sudden temperature change is possible due to the low specific heat of the highly expanded gases. Most of the energy supplied takes care of the heat radiation which is extremely high at 6000° Kelvin. Much of the heat radiated, however, is returned to the working focus after two or more reflections. This gives the apparatus high thermal efficiency. The electrical efficiency is also good due to the reflections. The effect of the reflections on the dipole is to decrease its resistance. It is not a serious problem, however, to match this lowered radiation resistance.

The dipole at the focus 2 is subject to a concen-

tration of heat and radio waves almost as much as the material in the working focus 3. It is important, therefore, that the dipole be composed of a metal capable of withstanding high temperatures and that it be polished. The pipes 12 for the cooling fluid may be connected to hollow conductors constituting the transmission line 10 in order that the cooling fluid may reach the dipole. Live steam may be used for absorbing the heat, or other fluids may be used optionally.

In addition to high temperatures the apparatus shown in Fig. 2 is also capable of generating extreme intensities of light. The temperature of the gases is about the same as on the surface of the sun, giving the greatest intensity in green.

In a practical embodiment of my invention the vessel 1 may be built to have a ten-foot length along its major axis. The average radio-frequency power input may be of the order of 1.6 kw. at approximately 3,000 mc., while the direct current for the arc may be about 10 kw. Almost all of this energy must be dissipated through the wall of the vessel 1, and in so doing its temperature may be raised to just below red heat.

The ellipsoid vessel 1 may be made of cast steel with heavy copper plating inside, polished to a mirror finish. If the copper tends to react with the various chemicals within the ellipsoid, it can be replaced by some noble metal like platinum or iridium. A quartz lining inside this vessel is also feasible.

As an example of what practical results could be accomplished with this invention, the extraction of aluminum from clay may be cited. There is a great abundance of aluminum on earth, but so far its removal was only possible from bauxite, a mineral found only in a few parts of the globe.

Among the many uses to which my invention may be put, its use for the extraction of metals affords a sufficient illustration of how it may be made to operate. Assume, for example, that metals such as aluminum, sodium, potassium and magnesium are to be separated from clay. The process suggested is as follows:

The clay in the soft solid state is pumped by pump 14 thru pipe 13 into the ellipsoid, where it is first vaporized, then heated periodically to the temperature where chemical compounds can no longer exist. This happens at about 6,000° centigrade. The mechanical mixture of the various elements moved by convection currents cools off slightly after each heating period and the aluminum recombines with another element, such as oxygen. After this, the aluminum oxide condenses and solidifies on the bottom of the vessel, from where it is removed periodically. The bottom of the vessel may contain a dish of the proper shape adhering to the contour of the vessel, where this solidification takes place. It is this dish which is removed periodically. The aluminum oxide is then reduced by conventional means to pure aluminum.

Sodium, potassium and magnesium may also be freed from their compounds by heat as above and oxidized or otherwise recombined before cooling off completely.

The highest temperature available to the research chemist until the present, was the electric arc. With the use of this invention additional energy in the order of 100 kilowatts or more is supplied to a substance which has reached about the highest temperature the ionized gas in the arc is capable of imparting to it.

The problem of a container capable of holding material at a temperature so high that matter

can exist only in a gaseous state is solved with this invention. Convection currents are used to carry matter in and out of the high temperature zone. In this way chemical compounds are first disintegrated and later new compounds formed.

While it is believed that my invention may be used for exploring many different physical phenomena, the basic principles are well illustrated in the example given above. The scope of the invention is not, therefore, restricted to what has been shown and described.

I claim:

1. A device for obtaining a high temperature in a limited space, comprising an ellipsoidal shell having an electro-magnetic radiant energy reflecting inside surface, an antenna centered at one focus of said shell, means for producing an arc discharge at the other focus of said shell, a substance to be heated situated in the path of said arc discharge for vaporization and ionization thereby and high frequency energy fed to said antenna, whereby radiant energy by radiation and reflection from the inner wall of said shell is directed to a point within said arc and is absorbed by the ionized vapors of said substance to produce a high temperature.

2. A device according to claim 1 in which the frequency of said energy is suitably chosen with respect to the distance of travel of the energy from said antenna to the inner wall of the shell and thence to the point of location of said arc so that the reflected rays of said energy will be cophasally concentrated on said substance.

3. Apparatus for the treatment of substances with extremely high temperatures, comprising a metallic ellipsoidal shell, having an electro-magnetic radiant reflecting inside surface, means for supporting a substance to be treated in a zone at the center of which is one focus of said shell, means for vaporizing the substance to be treated into an ionized gaseous medium in that zone, and means for radiating electromagnetic energy in all directions from the other focus of said shell, which energy upon reflection from the inner wall

of the shell is focussed on said substance and absorbed by the ionized vapor thereof.

4. Apparatus according to claim 3 wherein said means for vaporizing the substance into an ionized gas includes a power supply connected to electrodes across which an arc discharge is produced.

5. Apparatus according to claim 3 and including a window in said shell, said window being glazed with a transparent heat resistant material, such as quartz, whereby said substance may be observed while being subjected to heat treatment.

6. Apparatus according to claim 3 wherein said shell is composed of two flanged parts the flanges of which are bolted together during a process of heat treatment, the parts being separable for obtaining access to said substance.

7. Apparatus according to claim 3 wherein the inner wall of said shell is lined with quartz.

8. Apparatus according to claim 3 further including a gas compressor to maintain the inside of said shell at a given higher than normal pressure.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
886,856	Price	May 5, 1908
2,245,669	Hollmann	June 17, 1941
2,364,526	Hansell	Dec. 5, 1944

OTHER REFERENCES

Hershberger et al., "Thermal and Acoustic Effects Attending Absorption of Microwaves by Gases," RCA Review, September 1946, vol. VII, No. 13, pages 422-431, particularly pages 422, 423 and 428.

"Engineering Abstracts," Product Engineering, January 1947, pages 137-140, particularly page 138.