Sept. 4, 1956 M. VERON ET AL 2,761,619

COMBUSTION CALCULATOR

Filed June 30, 1952

Fig. 2

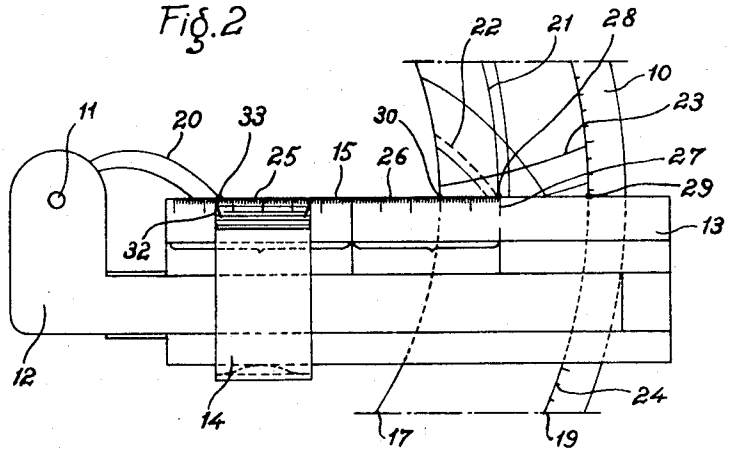
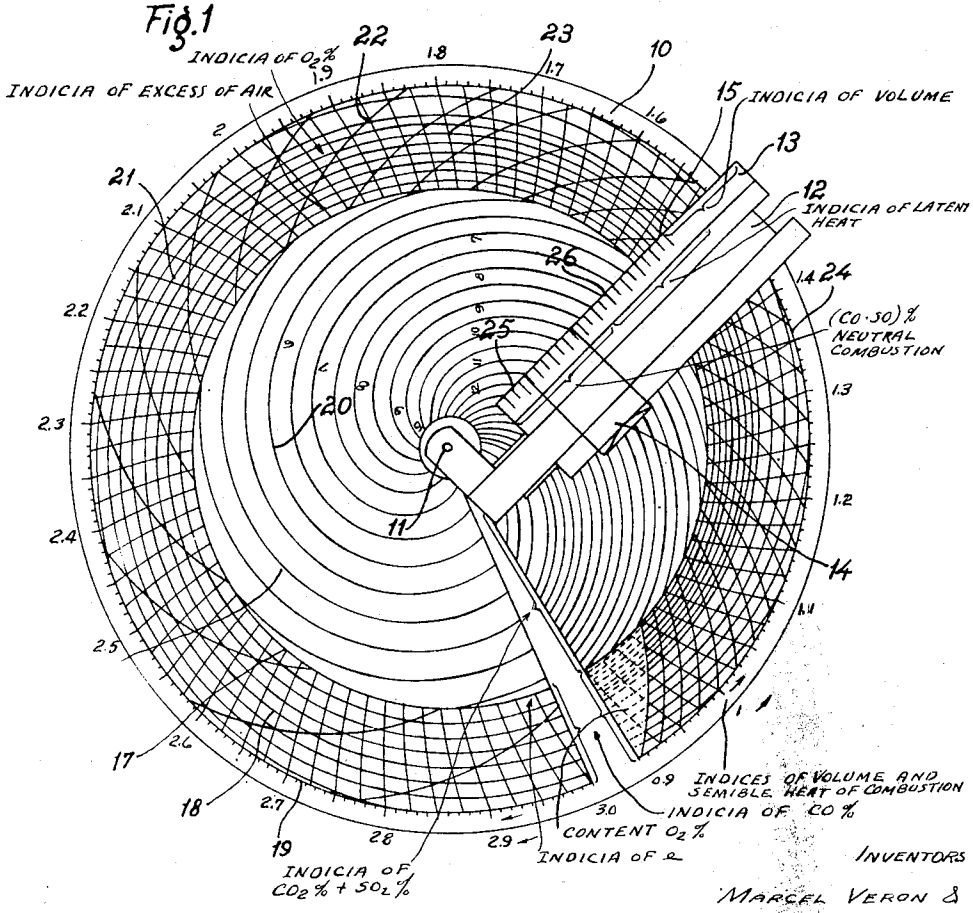


Fig. 1



INVENTORS
MARCEL VERON &
ANDRE DUMEZ
By Young, Emery & Thompson
ATTYS.

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COMBUSTION CALCULATOR

Marcel Veron, Neuilly-sur-Seine, and André Dumez, Saint-Cloud, France

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2 Claims. (Cl. 235—61)

The present invention has for its object to provide a combustion calculator, that is to say a device enabling the conditions of a combustion to be determined from the indications of the volumetric anaylsis of the products of combustion, and also the modifications to be made to the air control so as to improve the combustion.

One of the special features of the invention consists in that the combustion calculator can be used directly for all types of fuel and for all types of combustion, whether the latter are neutral, oxidizing or reducing in their nature.

A further feature of the invention resides in that the combustion calculator is simple to operate and gives easy and exact readings.

The attached drawings illustrate the combustion calculator in accordance with the invention.

Fig. 1 is a plan view;

Fig. 2 is a partial detail view to a larger scale.

The combustion calculator consists of a disc **10** in the center of which is mounted a shaft **11**. On this shaft is mounted a pivoted slide-rule **12** carrying a graduated sliding plate **13**. A curser **14** is adapted to slide on the plate **13**. The edge **15** of the plate **13** is aligned with the shaft **11** in such a way that the edge **15** is always placed along a radius of the disc **10**.

The disc **10** comprises a central portion **16** bounded by a circle **17** and an annular portion **18** included between the circle **17** and the external circle **19**. Inside the zones **16** and **18** are traced several families of graduated curves. In the central portion there is drawn a family of Archimedean spirals **20** graduated and representing the values of the proportions α of carbon dioxide CO_2 contained in the smoke generated by the combustion.

In the annular portion **18** are drawn two series of curves; the curves **21** which are portions of Archimedean spirals representing the proportions β of carbon monoxide CO contained in the smoke, the curves **22**, which are also portions of Archimedean spirals, presenting the values of the proportions ω of oxygen O_2 contained in the smoke.

The justification of the shape and the description of these curves **20**, **21** and **22**, results from the analytical transformation of the chemical equations of combustion. (The corresponding calculations have been given in detail in the Bulletin Technique de la Société Française des Constructions, Babcock & Wilcox, No. 25, October 1952.)

In addition to the curves **21** and **22**, there may also be drawn inside the annular space **17**, the portions of curves **23** representing the values of the excess air χ in the products of combustion; these curves are also Archimedean spirals.

The various curves **21**, **22** and **23** intersect each other at sufficiently wide angles to permit of easy and accurate reading, while in the usual types of combustion diagram, the network of the lines of equal values of α, β, ω, and χ are groups of convergent straight lines, the density of the groups often making readings both difficult and inexact.

The external circle **19** carries a graduation **24** of values of the sensible heat q of the smoke or indices of the volume v of the smoke. The index v expresses the ratio of volume of smoke actually produced by the combustion of a unit mass of fuel to the volume of smoke which would be produced by a neutral combustion of a unit mass of the same fuel.

The edge **15** of the plate **13** is marked with graduations **25** representing the values of the content α_0 of carbon dioxide CO_2 in the smoke which would be theoretically produced in the neutral combustion of the fuel considered. In addition, a further series of graduations **26** is arranged on the edge **15**, representing the values of the indices l of latent heat contained in the products of combustion. This latent heat corresponds to the quantities of heat which could be supplied by the combustible gases, carbon monoxide CO, hydrogen H, hydro-carbons, contained in the smoke. The datum point **27** at the extremity of the scale **26** corresponds to the value $l=0$.

The combustion calculator which has just been described enables solutions to be found directly and without calculations of the problems presented by the combustion of all fuels. It should be noted that the graduations express the values of the quantities α, β, ω, χ, v, l, q, which are ratios independent of the nature of the fuel chosen. The calculator can thus be used for all the usual fuels, solid, liquid or gaseous.

A few examples of solutions of the problem of combustion are given below.

(1) The proportions β of carbon monoxide CO and ω of oxygen O_2 contained in the smoke are known.

The spirals **21** and **22** corresponding to the values β and ω are marked off or alternatively the curves which correspond to the values β and ω are estimated by interpolation between the nearest corresponding curves of the family of curves **21** and **22**.

The intersection of these curves gives the figurative point **28**. Through this point passes a curve **23**, real or interpolated, the value of which gives the index of excess of air x.

The edge **15** of the rule **13** is now brought on to the point **28** and at **29** on the external graduation **24**, the value of the index of volume v is read off. By causing the latter to slide so that the datum point **26** comes opposite the point **28**, the value of the index l of latent heat can then be read at **30** on the graduation **26** opposite the circle **17**.

The curser **14** is then moved along its slide until its index such as **32** reaches a position on the value of the scale **25** which corresponds to the value α_0 of the fuel used, this value being known beforehand and varying in practice from 15 for a light fuel to 20.5 for coke. The point **33** of the corresponding edge **15** comes on a curve **20** or between two graduated curves **20**, giving the value of α (the proportion of CO_2) of the real combustion.

(2) The proportions α of carbon dioxide CO_2 and ω of oxygen O_2 contained in the smoke are already known.

The curser **14** is moved along the rule **13** in such a way that its index **32** comes opposite the value of the graduation **25** corresponding to the known index α_0 of the fuel used at **33**, and that the datum mark **27** falls on the curve **22** corresponding to the value ω.

The rule **12** is now rotated and the plate **13** is moved along at the same time so as to bring the point **33** on to the curve **20** corresponding to the value α.

Opposite the datum mark **27** of the plate **13**, the values β (content of CO) and x (excess of air), can be read off directly on the curves or between the curves **21**, **22** and **23** respectively.

The value of v is read at **29** on the scale **26**, and the value of l at **30** on the same scale.

(3) The values of the proportions α of the carbon

dioxide CO_2 and β of carbon monoxide present in the smoke, are already known.

By sliding the curser **14**, the index **32** is brought opsite the value of the graduation **25** giving the value α_0 of the fuel utilized.

By rotating the rule **12** and sliding the plate 13, the datum mark **27** is brought on to the curve **21** corresponding to the value β and at the same time the datum **32** is brought on to the curve **20** corresponding to the value α.

The values of the contents of oxygen ω and excess of air x are read off on or between the curves 22 and 23 respectively. The value v is read off at **29**, and the index l at **30**.

(4) The values of the proportions $\alpha(CO_2)$, $\beta(CO)$ and $\omega(O_2)$ contained in the smoke are already known.

The datum mark **28** having been brought to the intersection of the curves **21** and **22** corresponding to β and ω, the index **32** brought to the value α_0 of the scale **25** should come on to the curve **20** corresponding to α. If not, the analysis is wrong.

If the value of α_0 is not known, this can be taken from the scale **26** by bringing the index **32** on to the curve 20 corresponding to the value α.

It will be seen that, by means of the combustion calculator described, there may be obtained directly and very rapidly, starting from the proportions of two constituents of the smoke, all the elements necessary for the regulation of the combustion; excess or shortage of air, sensible or latent losses of the smoke.

What we claim is:

1. A combustion calculator comprising a stationary circular carrier surface including a central circular area and an annular area concentrically enclosing the central area, the latter being provided with a group of scale-carrying Archimedean spirals defining values of the contents of carbon dioxide in the combustion gases and the annular area carrying two groups of spiral curves crossing each other, the first series forming a scale of contents of carbon monoxide in the combustion gases and the second series forming a scale of contents of oxygen in the combustion gases, an index bar pivotally secured to the center of the circular carrier surface, a ruler slidingly carried by the index bar to move longitudinally thereof and carrying a scale of contents of carbon dioxide in the neutral combustion gases and a reference runner slidingly carried by the index bar.

2. A combustion calculator comprising a stationary circular carrier surface including a central circular area and an annular area concentrically enclosing the central area, the latter being provided with a group of scale-carrying Archimedean spirals defining values of the contents of carbon dioxide in the combustion gases and the annular area carrying three groups of spiral curves crossing one another, the first series forming a scale of carbon monoxide contents in the combustion gases and the second series forming a scale of oxygen contents in the combustion gases, the third series forming a scale of percentages of excess of combustion air, a circular scale of indicia of volumes of combustion gases and of free heat in the combustion gases, said circular scale being carried on the outside of the annular area by the carrier surface, an index bar pivotally secured to the center of the circular carrier surface, a ruler slidingly carried by the index bar to move longitudinally thereof and carrying two scales indicating respectively the contents of carbon dioxide in the neutral gases and the indicia of latent heat in the combustion gases, and two reference runners slidingly carried by the index bar and rigid with each other.

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