C. C. THOMAS.

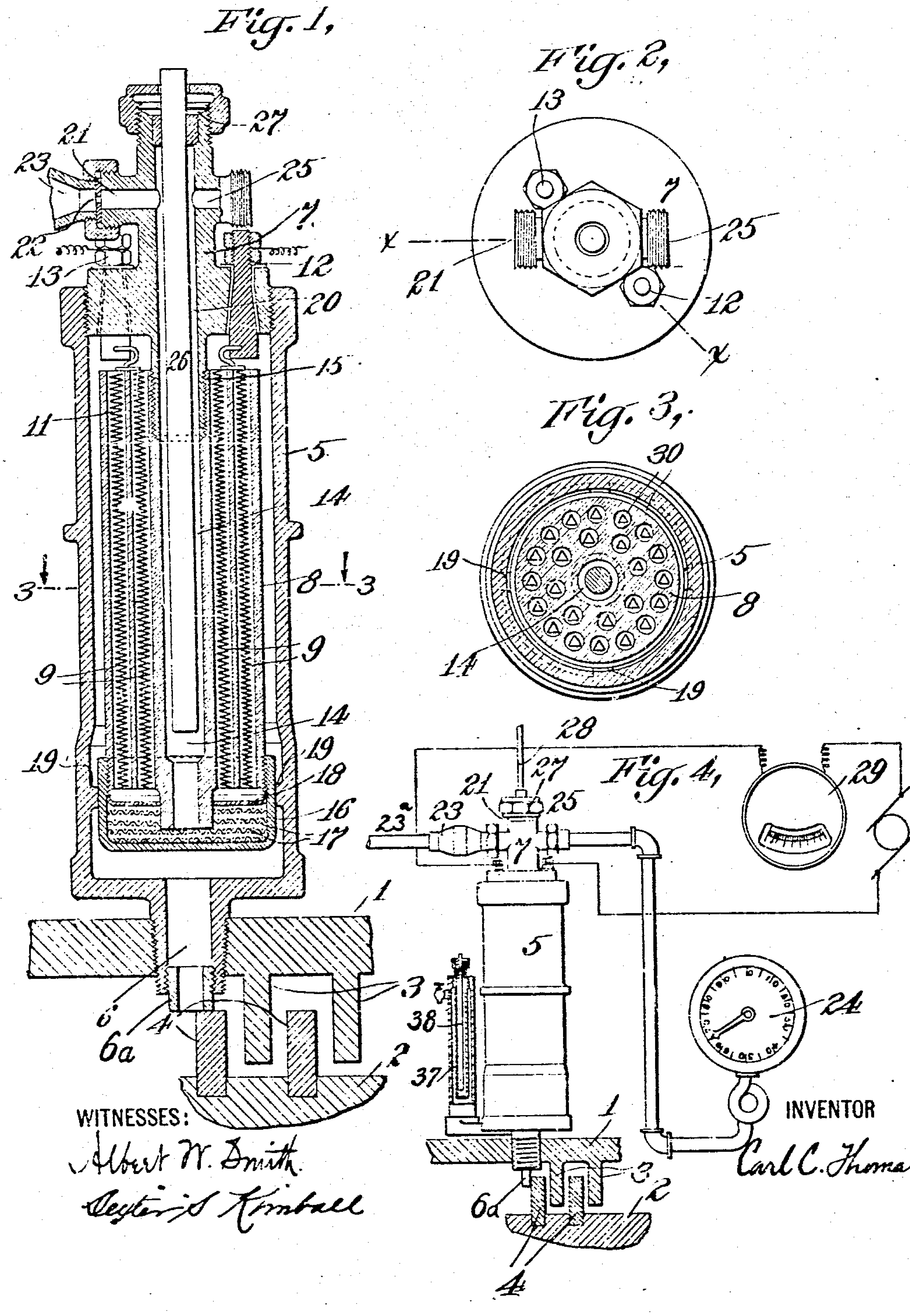
STEAM CALORIMETER.

APPLICATION FILED SEPT. 29, 1906.

898,610.

Patented Sept. 15, 1908.

2 SHEETS—SHEET 1.



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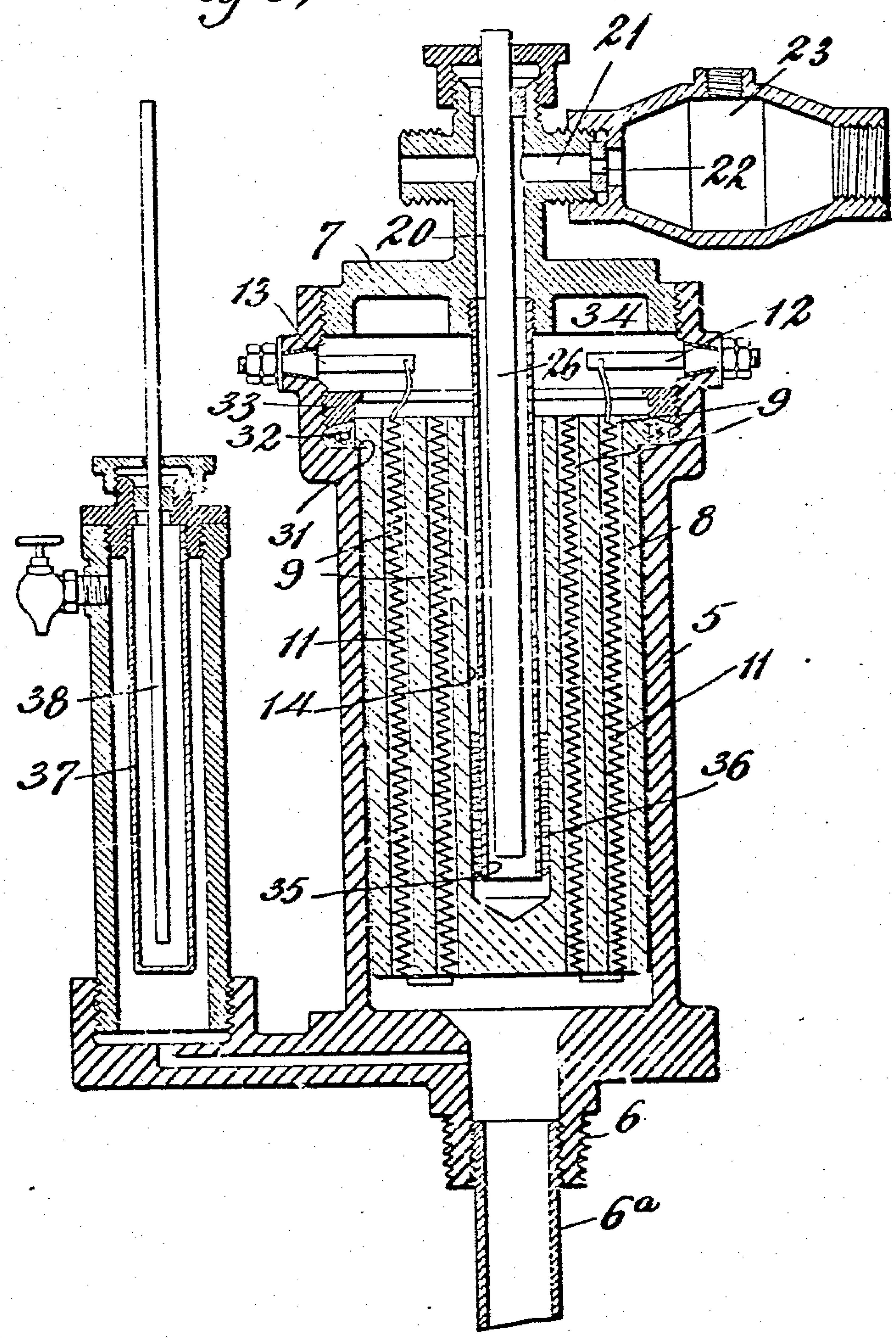
2 SHEETS—SHEET 2.

Fig. 5,



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STEAM-CALORIMETER.

No 898,610. Specification of Letters Patent. Patented Sept. 15, 1908.

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To all whom it may concern:

Be it known that I, CARL C. THOMAS, a citizen of the United States, residing at Ithaca, in the county of Tompkins and State of New York, have invented certain new and useful Improvements in Steam-Calorimeters; and I do hereby declare the following to be a full, clear, and exact description of the same, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to improvements in steam calorimeters, and comprises means whereby the proportion of moisture present in steam at any given instant may be determined readily.

My improved calorimeter is adapted for the same uses as ordinary steam calorimeters, but is particularly intended for analyzing the performance of steam turbines, for which use ordinary steam calorimeters are not well adapted and for which use there has not heretofore been any suitable instrument.

In steam turbines to which is supplied dry but unsuperheated steam, or steam which, though initially superheated, has not such degree of superheat that it does not become wet during its passage through the machine, the moisture present in the steam at any particular point in the turbine bears a direct ratio to the amount of work done by the steam in the turbine up to that point. If the steam supplied to the turbine be either moist or superheated, a suitable correction may be required, but such correction is easily made. By determining the quality of the steam (which is the term used by engineers in referring to the percentage of moisture carried by steam) at a number of different points in the turbine, and plotting the results thus obtained, an accurate indication of the performance of the turbine is obtained. In fact, by so using a calorimeter, the performance of the turbine may be investigated and analyzed as readily as the performance of a reciprocating steam engine may be investigated and analyzed by means of a steam engine indicator.

The calorimeter herein illustrated and described is designed to be attached successively at different points along the casing of a steam turbine while the said turbine is running under substantially constant conditions, and to draw off samples of steam from such turbine at the various points at which it is connected, and to show the quality of the steam of each such sample. To indicate the quality of the steam of such samples I adopt the expedient of heating the steam to remove the moisture and determining the amount of heat required (in proportion to the rate of passage of the steam through the calorimeter) to bring the steam to absolute dryness. This I do preferably by means of an electric current passing through resistance coils past which the steam is caused to flow. By determining the rate of flow of the steam through the calorimeter (very simple means for doing this with great accuracy will be described hereafter) and by measuring the amount of electrical energy absorbed in bringing this steam to absolute dryness (an indicating ammeter or watt meter and a thermometer to indicate rise of temperature of steam above that of unsuperheated steam at corresponding pressure will show this) the observer obtains readily the percentage of moisture in the sample of steam tested.

It will be seen that a calorimeter operated on this principle gives continuous readings, and from each set of readings the quality of the steam tested at the particular instant the reading is taken may be determined without reference to previous readings. Furthermore, the accuracy of the instrument is not dependent upon the mechanical removal of all traces of moisture from the sample of steam tested (a matter of great difficulty) or upon observation of weight of steam condensed, (a somewhat rough and slow method giving accurate results only in the hands of skilful and experienced observers and requiring bulky apparatus). The accurate determination of the temperature of steam by means of accurate or accurately calibrated thermometers or equivalent temperature-measuring instruments, is a very simple matter; and the temperature of saturated steam for different pressures having already been accurately determined and being shown in various published steam tables, the slightest rise of temperature of the steam tested above that of saturated steam at corresponding pressure, as shown by steam tables, indicates that the steam tested has been completely dried and superheated to the extent of the excess of the thermometer reading over the temperature of saturated steam at the corresponding pressure.

Owing to the great facility with which the flow of electric current through the heating coils of the instrument may be regulated, such degree of superheat in the instrument should always be very slight, and should be substantially the same at all times, and will ordinarily be negligible. But if desired, correction for such superheat may be made readily, as will be obvious to those skilled in the art.

My invention consists in a calorimeter comprising means for heating the steam tested to dryness, and for observing the amount of heat required for such purpose; in the general construction of the instrument; and generally in the features hereinafter described and particularly pointed out in the claims.

The objects of my invention are to analyze the performance of steam turbines; to improve and simplify steam calorimeters; to make the calorimeter adaptable for any class of work for which steam calorimeters are commonly used; to provide a calorimeter adaptable to the determination of the quality of steam in different portions of a steam turbine; and to make the instrument simple, compact, accurate and reliable.

I will now proceed to describe my invention with reference to the accompanying drawings, in which one form of calorimeter embodying my invention is illustrated, and will then point out the novel features in claims.

In the said drawings: Figure 1 shows a longitudinal vertical section of my improved calorimeter on the irregular line $x—x$ of Fig. 2, a portion of a turbine being also indicated diagrammatically with the calorimeter attached thereto. Fig. 2 shows a top view of the calorimeter and indicates particularly the location of the discharge and pressure gage connections, and the circuit terminals. Fig. 3 shows a transverse horizontal section through the heating chamber of the calorimeter, and indicates means which may be employed for causing the stream to pass in close proximity to the heating coils. Fig. 4 is a diagrammatic view illustrating my said calorimeter attached to a turbine (the latter indicated diagrammatically) with pressure gage and electrical connections. Fig. 5 is a view similar to Fig. 1, illustrating an alternative construction of my improved calorimeter.

Referring now to the accompanying drawings and at first to Figs. 1–3 inclusive, 1 designates the casing of the turbine, 2 a portion of the rotor of such turbine, and 3, 3 and 4, 4 blades of the casing and rotor respectively. 5 designates the said calorimeter. It comprises a hollow casing arranged to be connected to an orifice in the casing of the turbine by a threaded nipple 6, provided with a sampling tube 6^a. The top of this casing is closed by a head 7 provided with circuit terminals and with a passage for the outflow of the steam, and with means for admitting a thermometer and for the attachment of a steam gage, all as hereinafter described.

Within the casing of the calorimeter is a cylinder 8 of electrical insulating material adapted to withstand the temperature of the steam (soapstone is one material suitable for the purpose) having within it a series of longitudinal perforations 9 extending from end to end and containing the resistance heating coils 11. These coils are electrically connected to each other and as a whole are connected to circuit terminals 12 and 13 carried by the head 7. The cylinder 8 has a central bore 14 extending from one end to the other, the upper portion of said bore enlarged and screw-threaded to screw over the end of a depending neck 15 forming a part of the head 7 of the calorimeter casing; whereby the said cylinder is supported. At its lower end said cylinder 8 carries a cap 16 screwing upon the lower end of said cylinder, and between said cap and the lower end of said cylinder 8, there are a number of screens or diaphragms of wire gauze or the like 17, and a perforated plate 18 forming a backing therefor. Lugs 19 projecting from the sides of the casing of the calorimeter steady the cylinder 8 at its lower end; and between said lugs the steam passes upward around the cylinder 8 to the upper end thereof, and thence through the passages 9 in said cylinder to the lower end thereof and through the plate 18 and screens 17 and the internal bore 14 of the cylinder 8, up through the internal bore 20 of the head 7 of the calorimeter, and out through discharge passage 21. At the end of said discharge passage 21 I provide a plate having in it a calibrated orifice 22, and beyond said plate there is a discharge chamber 23 leading to a condenser or to the atmosphere or to any other suitable discharge. A pressure gage 24 connected to the calorimeter at 25 serves to show the pressure at which the steam is discharged from the calorimeter. By means of this steam gage 24 and calibrated orifice 22 the rate of flow of steam through the calorimeter may be determined instantly and with great accuracy; since the rate of flow of dry steam through a small orifice at constant pressure is very uniform. Chamber 23 is provided with a connection 23^a for the attachment of a pressure or vacuum gage, mercury column, or the like.

26 designates a long thermometer cup inserted through a stuffing box 27 at the top of the head 7, and projecting downward nearly to the bottom of the cylinder 6. By means of a sensitive thermometer 28 (Fig. 4) placed in such a tube, it is possible to measure with great accuracy the temperature of the steam passing through the calorimeter. As will be readily understood, the temperature of unsuperheated steam is independent of the amount of moisture carried by it, and for the same pressure is always the same. The pub-

lished steam tables give the temperature of unsuperheated steam through a wide range of pressures. The temperature of steam cannot rise above that corresponding to the pressure existing at the moment, until the moisture suspended in the steam shall have been evaporated and the steam is absolutely dry. A slight indication in a thermometer placed within thermometer cup 26 of a temperature above that of saturated steam of the pressure of the steam in the calorimeter, shows that all suspended moisture in the steam has been evaporated and that superheat of the steam has commenced. Instead of using pressure gage 24, or as a check thereon, I may provide a thermometer cup 37 (Fig. 4), exposed to the steam as it enters the calorimeter. A thermometer placed in this cup will show the temperature of the entering steam, and from this the steam pressure may be obtained by referring to steam tables.

In Fig. 5 I illustrate an alternative construction of calorimeter, in general similar to that shown in Fig. 1, except in the details of construction and arrangements hereinafter mentioned. The soapstone cylinder 8 is provided with a shoulder 31 resting upon a corresponding shoulder of the outer casing 5 of the calorimeter. Outside this shoulder 31 is placed packing material 32, and a gland 33 screwing into the casing 5, compresses such packing material. In this form of calorimeter, the steam passes upward through the passages 9 containing the heating coils 11, into the chamber 34 above said soapstone cylinder, and thence passes down through the central bore 14 of this cylinder. Within said bore, but supported from the top 7 of the calorimeter, there is a tube 35, open at the lower end; and around the lower portion of this tube 35 are wrappings of gauze 36. The steam passes down through the annular space surrounding this tube 35, and through the gauze 36, whereby said steam is thoroughly distributed, and thence passes up through the inside of tube 35, in the annular space between the inner wall of said tube and the thermometer cup 26, thence passing out through discharge chamber 23.

The form of calorimeter illustrated in Fig. 5 is preferable to that shown in Fig. 1, in that it is somewhat easier and simpler to construct.

Sometimes, instead of employing pressure gage 24 to show that pressure at which the steam passes through the calorimeter, or as a check upon the pressure gage, I provide a thermometer cup 37 connecting so as to receive steam at the same pressure and temperature as the steam entering the calorimeter, and in this cup place a thermometer 38. It being always possible to determine the pressure of unsuperheated steam, from its temperature, the thermometer 38 shows the pressure of steam entering the calorimeter as accurately as, and perhaps more accurately than, the pressure gage 24, and is furthermore a lighter and more compact piece of apparatus.

In Fig. 4, 29 designates an instrument by which the current flowing through the coils of the calorimeter at any instant may be measured.

In using this calorimeter in testing a steam turbine, the calorimeter is connected successively at different points along the path of steam through the turbine, one such point being preferably before the steam encounters the blades, and another after it has passed the last blades of the turbine, the other points being intermediate these two. In turbines of the Parsons type, for example, the calorimeter will customarily be connected successively to passages connecting the several rows or sets of casing blades. The quality of the steam withdrawn through the calorimeter at each such point of connection being determined, and the results plotted, a curve is obtained showing the quality of the steam at each point of its passage through the turbine and thus the relative work done by the steam in each portion of the turbine is indicated. In determining the quality of the steam, the steam tested flows through the inlet 6 of the calorimeter, around the cylinder 8, and thence through the passages 9 in said cylinder, over the heating coils 11 therein, to the central passage 14 (around the thermometer cup 26) and thence through the calibrated orifice 22 outward. Electric current is passed through the coils 11 in quantity sufficient to impart heat to the steam and as soon as it is known that the parts of the calorimeter are at the temperature of steam and therefore are not causing condensation, the flow of current is carefully regulated so that any slight increase of current flow will raise the temperature of the steam, as indicated by the thermometer cup 26, above the temperature of unsuperheated steam at the pressure shown on the pressure gage. The amount of current thus required to drive the steam being known, and the rate of passage of steam passing through the calibrated orifice 22 being known, it becomes a simple matter to calculate the number of heat units required to dry any convenient unit of steam and thence to determine the amount of moisture in the steam.

The sampling tube 6^a will be of a shape, construction etc., adapting it to take a fair sample of the entering steam. The use of sampling tubes in connection with steam calorimeters is well understood, and I have not attempted to illustrate any particular construction of such tube.

In order to insure passage of the steam in close proximity to the heating coils, I sometimes provide filling pieces such as the pieces 30 shown in Fig. 3, in the steam passages 9 containing the heating coils 11. These filling pieces fill the central portions of the passages 9, forcing the steam to pass directly over the heating coils. The filling pieces may be supported in any convenient manner; for example, their ends may rest upon the plate 18.

While it is not new, broadly, to determine the quality of steam by heating the same to dryness and determining the quantity of heat required to do so, apparatus for the purpose so simple, compact and self-contained and portable as that herein illustrated and described have not been used before, to my knowledge; nor have electrical resistance coils been employed before in such calorimeters to dry the steam, to my knowledge. By means of these resistance coils, it is possible to regulate the heating of the steam with great nicety and to determine accurately the amount of heat imparted to the steam; for it is an easy matter to measure accurately the electrical energy converted into heat in the instrument, the instrument employed for the purpose (an ammeter or wattmeter) being very portable and easily read, and being in its nature capable of great accuracy. The calorimeter constructed as shown is substantially free from features which are apt to lead to errors, uncertainty or inaccuracy in results.

When in operation the exterior of the calorimeter will be covered, lagged, or otherwise protected from heat radiation as is customary with such instruments.

While I have shown the calorimeter attached directly to the turbine, it will be understood that it may be attached by means of suitable and convenient pipes, valves, etc., such as are commonly used in connecting calorimeters to the source of supply of steam to be tested.

Instead of coils of resistance wire, any other suitable resistance material may be used in the calorimeter.

What I claim is:—

1. A steam calorimeter adapted to permit the flow of steam therethrough, and comprising electrical heating means, and electrically-operated measuring means for measuring the energy used.

2. A steam calorimeter adapted to permit the flow of steam therethrough, and comprising electrical heating means, electrically-operated measuring means for measuring the energy used, and means for measuring the rate of flow of steam through the calorimeter.

3. In a steam calorimeter, the combination with a chamber adapted to permit the flow of steam therethrough, of an electrical heating coil in said chamber in the direct path of the steam, and means for measuring the energy used.

4. In a steam calorimeter, the combination with a chamber adapted to permit the flow of steam therethrough, of an electrical heating coil in said chamber in the direct path of the steam, means for measuring the energy used, and means for measuring the rate of flow of steam through said chamber.

5. In a steam calorimeter, the combination with a chamber adapted to permit the flow of steam therethrough, of an electrical heating coil in said chamber, means for measuring the rate of flow of steam through said chamber, and means for measuring the flow of current through said coil.

6. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, a support of insulating material within said chamber, and an electrical resistance coil on said support, said support having means for distributing the steam and for passing all parts of same in close proximity to said coil, and means for measuring the flow of current through said coil.

7. In a steam calorimeter, the combination of a chamber adapted for the flow of steam therethrough, a body of insulating material therein having passages therethrough for the flow of steam, and resistance heating coils in said passages in the direct path of the steam.

8. In a steam calorimeter, the combination of a chamber adapted for the flow of steam therethrough, a body of insulating material therein suspended from one end, whereby expansion of said chamber relative to said body of insulating material is permitted, and heating coils carried thereby.

9. In a steam calorimeter, the combination of a chamber adapted for the flow of steam therethrough, and means within said chamber comprising a passage for the flow of steam and a heating coil in said passage in the direct path of the steam.

10. In a steam calorimeter, the combination of a chamber adapted for the flow of steam therethrough, means therein, having a paassge for the flow of steam, and a heating coil in said passage, in the direct path of the steam passing through such passage.

11. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, a heating coil therein, in the direct path of the steam, temperature-determining means and steam-distributing means interposed in the path of the same between said heating coil and temperature-determining means.

12. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, means therein provided with a passage for the flow of steam and with a heating coil in said passage, means for determination of temperature of the

steam, and steam distributing means interposed in the path of the steam between said temperature determining means and said coil.

13. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, means therein provided with a passage for the flow of steam and with a heating coil in said passage, means for determination of the temperature of the steam, and foraminous metal interposed between said coil and temperature determining means.

14. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, means therein provided with a passage for the flow of steam and with a heating coil in said passage, a thermometer cup beyond said heating coil, and steam distributing means between said cup and said heating coil.

15. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, and a body of insulating material therein provided with electrical heating coils and with a thermometer cup.

16. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, a body of insulating material therein provided with electrical heating coils, a thermometer cup, and steam distributing means surrounding said cup.

17. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, a body of insulating material therein provided with electrical heating coils, a thermometer cup, and foraminous metal surrounding said cup.

18. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, a perforate support within said chamber having holes for the flow of steam and heating coils therein and having another hole therein for the return flow of the steam, a tube therein leading to the discharge of said chamber, and means in said tube for determining the temperature of the steam.

19. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, a perforate support within said chamber having holes for the flow of steam and heating coils therein and having another hole therein for the return flow of the steam, a tube therein leading to the discharge of said chamber, means in said tube permitting determination of the temperature of the steam, and distributing means for distributing the steam prior to contact with said temperature determining means.

20. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, a perforate support within said chamber having a steam passage, and a heating coil therein, and having also another passage, a tube within said latter passage, foraminous material surrounding said tube, and means within said tube for determination of the temperature of said steam.

21. In a steam calorimeter, the combination of a chamber adapted to permit the flow of steam therethrough, a perforate support within said chamber having a steam passage, and a heating coil therein, and having also another passage, a tube within said latter passage, foraminous material surrounding said tube, and a thermometer cup within said tube.

22. In a steam calorimeter, the combination of a chamber adapted for the flow of steam therethrough, a body of insulating material therein having a passage for the flow of steam, a heating coil in such passage, and a filling piece in such passage arranged to cause the steam to pass in close proximity to said coil.

In testimony whereof I affix my signature, in the presence of two witnesses.

CARL C. THOMAS.

Witnesses:
DEXTER S. KIMBALL,
ALBERT W. SMITH.