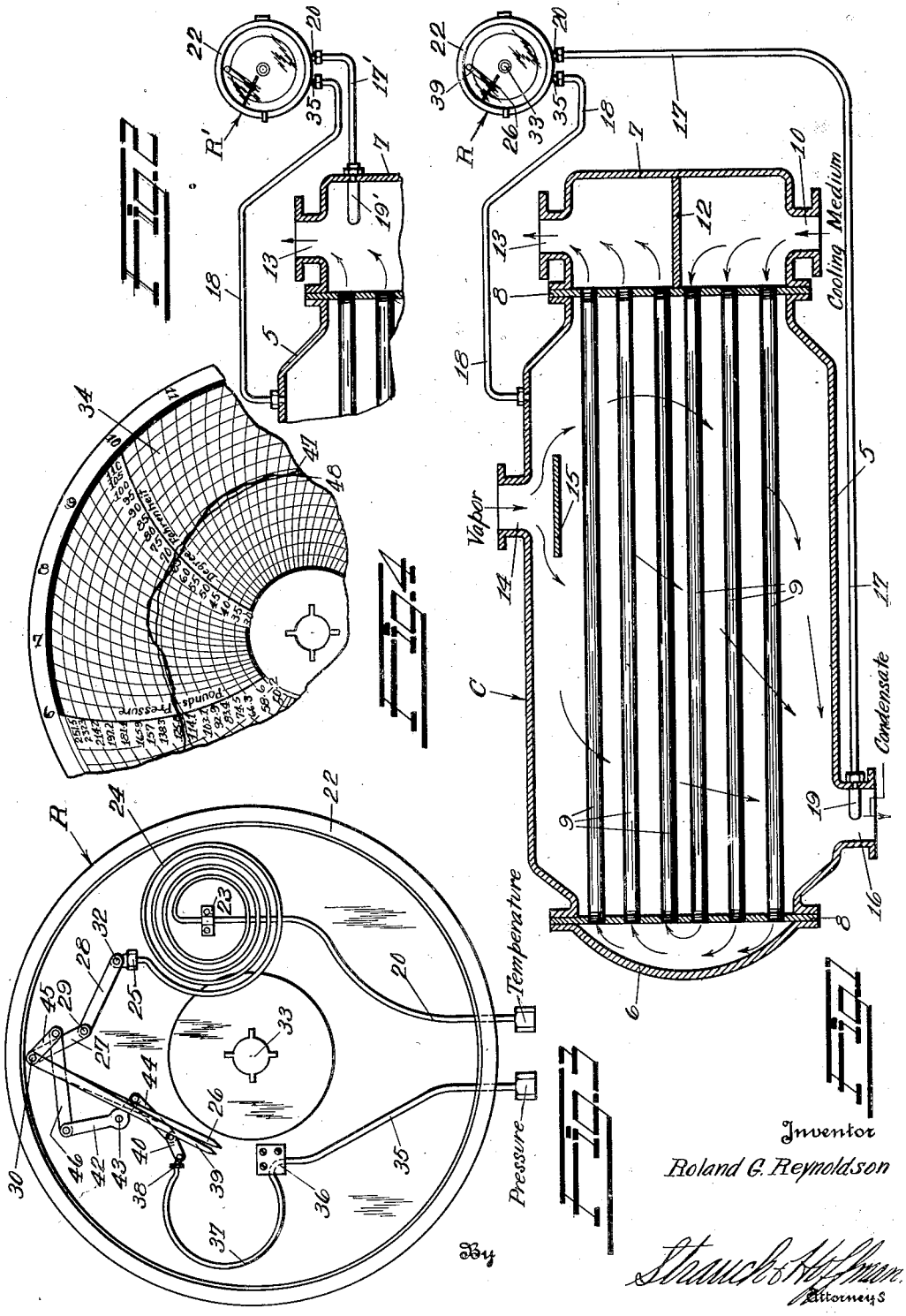
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SYSTEM FOR INDICATING WORKING CONDITIONS OF CONDENSERS AND THE LIKE

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SYSTEM FOR INDICATING WORKING CONDITIONS OF CONDENSERS AND THE LIKE

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This invention relates to a system for indicating the working conditions and operating efficiency of fluid pressure apparatus such as condensers and the like. More particularly, the invention is concerned with a system embodying a combination gauge or instrument, responsive to pressure and temperature, designed to afford an easily readable indication of whether or not the pressure and temperature conditions bear a predetermined proper relationship to one another.

The present invention is based upon two principles, one of which is Dalton's Law of Partial Pressures, viz., that: The total pressure of a mixture of gases is equal to the sum of the separate pressures which the gases would exert if each alone occupied the whole volume. The other principle is that, in a system where certain pressures in one part of the system bear a definite relationship to certain temperature conditions existing in another part of that system during proper operation of the latter, any indicated variation in said relationship will show that the system is not operating at desired efficiency. Each of these principles, and a combination of the two, may be utilized to locate the source of certain inefficiencies of the system.

Although, as above generally outlined, the invention is capable of wide and varied use, it will be particularly described and disclosed in connection with a vapor condenser for steam, ammonia, or the like.

Excessive pressures (inadequate vacuum) may arise in condensers, whether the vapor to be condensed is normally either above or below atmospheric pressure, due to such causes as air leakage into the system, dirt in the condenser, baffles or division plates carried away, inefficient separating pumps, insufficiency of cooling medium, too high a temperature of cooling medium, or uncompensated height of the barometer. It is essential that an adequate vacuum be maintained, not only to operate at high efficiency the engines or other apparatus exhausting into the condenser, but also to attain a proper efficiency for the condenser and the plant as a whole; and, accordingly, it is a major object of my invention to provide means for showing, at a glance, that one or more of the above mentioned factors is causing excessive pressure.

If a perfect vacuum were created in the condenser, the absolute pressure would be zero, i. e., 14.7 pounds below atmospheric pressure when the barometer stands at 30″. When only a partial vacuum is created, a corresponding absolute pressure will exist. For saturated vapor, or a mixture of the vapor and its liquid, the absolute pressure is a function of the temperature and hence, if the vapor in a condenser were pure (free from air and other non-condensible gases) its temperature could be taken and its absolute pressure calculated therefrom. However, it is practically impossible to have air-free vapor in a condenser, and hence the temperature of the vapor indicates only that pressure due to the pure vapor present. The total pressure is greater, being the sum of that of the pure vapor and that due to air or other gases present.

If the vacuum gauge fitted on the condenser is accurate, the absolute pressure can be obtained by calculating the difference between the gauge and barometer reading. The difference between the absolute pressure, thus obtained, and the absolute pressure corresponding to the temperature of the vapor (obtained from saturated vapor tables) represents the partial pressure of any air or other foreign gas present. That is, if air is present, the thermometer indicates a better vacuum than actually exists. This method of determining inefficiency by calculation is too complicated. Some means should be provided for mechanically indicating or recording the working conditions so that quick readings may be had and immediate steps taken to correct the conditions contributing to the plant inefficiency. I have found that such a means can be formed from pressure and temperature responsive instruments, designed and correlated in any one of several ways, as follows.

The combination instrument may comprise a thermometer having an element responsive to the temperature within a gaseous space

(the condenser) and designed to record such temperature in terms of that pressure which a particular vapor, such as steam known to be within said space, should have at said temperature; and a pressure-responsive element designed to record the actual total pressure within the space. These elements preferably are so related, as by specially designing either or both of them, that their indicators will be in substantial coincidence whenever the vapor is pure, i. e., when the total indicated pressure is one that actually corresponds with the temperature of the vapor. The indicators may consist of pens, and a common chart may be provided upon which said pens may record the temperatures and pressures. If the lines drawn are in coincidence, the vapor is pure; but if the lines are spaced, the degree of spacing represents a corresponding amount of foreign vapor or gas within the condenser. The method, then, may generally be said to consist in graphically indicating the total absolute pressure of a vapor in selected units; and graphically indicating, for purposes of quick comparison, the temperature of the vapor in units corresponding to that absolute pressure which the vapor, if pure, would have at the measured temperature.

In the exhaust connection to a condenser the ratio of air to the vapor (e. g., steam) is so small that the air has very little effect on the temperature, so that a thermometer inserted in such connection will indicate a temperture that substantially corresponds to the existing vacuum. But as the vapor passes downwardly and condenses, the proportion of air to vapor increases rapidly, and when the condition is reached where there are equal weights of air and vapor, a thermometer at this point will show a temperature, (corresponding to the partial pressure of vapor only) that may be 10 or 20 degrees lower than that corresponding to the total absolute pressure of the vapor and air. The thermometer might show 79° F. corresponding to a vacuum of 29″ and the gauge show only 28″, yet both would be correct for what they are designed to measure. For these reasons it is preferable to connect the thermometric element into the condenser at a point substantially spaced from the vapor inlet in order that the presence of air may be clearly indicated on the combination instrument. For example, the thermometer bulb may be disposed within the outgoing condensate. In such instances, however, the instrument affords only an indication of the presence of foreign gases and gives no proper indication that the condenser may be operating inefficiently from other causes. Hence, in the preferred form of my invention, the bulb is inserted in the discharge of the cooling medium.

Under the usual conditions of condenser design, the temperature of the circulated cooling medium rises about 15° or 20° during its passage through the condenser. To obtain economy in heating feed water and to lessen absorption of air, the discharged medium should leave at as high a temperature as will produce the desired vacuum. This temperature should be, for example, in a particular plant approximately 4° to 8° below that temperature which corresponds with the vacuum. By making proper allowance for this 4° to 8° difference in temperatures, the temperature responsive mechanism may be so designed that, with its bulb located in the cooling discharge, its indicator will record values in terms of the absolute pressures which should exist within the condensing space at temperatures 4° to 8° lower than those to which the bulb is actually subjected. It follows that, if the vapor in the said space is pure, the pressure and temperature indicators will draw coincident lines on the chart. However, lack of coincidence will show not only the presence of foreign gases, but also other causes of inefficiency such as dirty condenser, scale on tubes, plates carried away, insufficient circulating medium, inlet temperature of circulating medium too high, etc.

The foregoing and other objects will appear in the following detailed description and its appended claims, when studied in conjunction with the accompanying drawing, wherein:

Figure 1 shows, somewhat diagrammatically, my invention as applied to a conventional condenser, the latter being seen in longitudinal section with the temperature responsive element connected into the outgoing condensate.

Figure 2 is a modified fragmentary view showing a portion of the condenser of Figure 1 with the temperature responsive element projecting into the discharged cooling medium.

Figure 3 is a face view of the efficiency indicator or recorder, showing the pressure and temperature responsive instruments combined for producing chart readings.

Figure 4 is a face view of a portion of a chart that has been taken from the recorder of Figure 3 after several hours service thereon.

With continued reference to the drawing, wherein like numerals are employed to designate corresponding parts, and with particular reference for the moment to Figure 1:

The letter C designates generally a complete condenser of any conventional type, comprising a body 5 forming a condensing chamber with the headers 6 and 7 at its ends. The headers are sealed from the chamber by vertical plates 8 between which are interconnected a plurality of pipes 9. The header 7 has an inlet opening 10 for a cooling medium

such as cold water, and a division plate 12 is provided for causing the inlet water to pass through a number of the lower pipes 9 into the header 6 from which it is passed into the upper or discharge end of the header 7 by way of a number of the upper pipes 9. An outlet opening 13 is provided at the upper end of the header 7 to discharge the cooling water.

The vapor (e. g., ammonia) to be condensed is led through an inlet opening 14, against a baffle 15 in the condensing chamber, to be deflected into contact with the cooled pipes 9. The resulting condensate is carried off through an outlet 16. When the condenser and its auxiliary equipment is operating efficiently, the temperature of this outgoing condensate will afford an indication of the temperature of the vapors being condensed. By taking this temperature, then, and simultaneously obtaining the pressure (vacuum) within the condensing space one can, by calculation and by reference to the ammonia tables, determine whether there is an excessive amount of foreign gas (air) in the condenser. It is practically impossible to exclude all air, but the plant attendant should be informed at all times whether or not the air is present in excess and thus causing costly inefficiency.

The present invention contemplates the addition of an automatic indicating system, responsive to the temperature and pressure just mentioned and from which readings may be obtained at a glance, for supplying the plant attendant with the necessary information. The indications preferably, but not necessarily are permanently recorded on a clock-controlled chart to show the performance of the plant throughout a long period of time.

My automatic system comprises a recorder R connected to the condenser by lines 17 and 18. The line 17 comprises a pipe terminating at one end in a bulb 19 which projects into the condenser outlet 16, and connecting at its other end with a steel tube 20. The latter (see Figure 3) projects into the casing 22 of the recorder, is fastened therein by a clip 23, and then is wound into the form of a hollow spiral spring 24 closed at its end by a cap 25. The tube and its spring, the pipe 17 and the bulb 19 are filled with a fluid such, for example, as mercury, so that in response to temperature variations in the condensate the spring 24 will coil or uncoil slightly to move the cap 25. Movement of the latter is transmitted to an indicating and recording pen 26 by way of a pair of links 27 and 28 that are pivotally interconnected at 29. The link 27 is connected to the pen and designed to swing therewith about a stationary pivot 30. The link 28 is pivoted, as at 32, upon the cap 25.

The recorder has a clock-controlled pin 33 upon which a chart 34 may be mounted for recordation of the temperatures throughout a 24 hour period. For clarity of illustration the chart is removed in Figures 1, 2 and 3, and shown separately in enlarged detail in Figure 4. It will be observed that the above described portion of the indicating system might be so designed as to record the temperature of the condensate in terms of absolute pressure corresponding to such temperature, and that the pressure thus recorded would be correct if the ammonia vapor were pure. However, there might be considerable air present and, since the thermometer would not indicate its presence, I combine a pressure gauge with the thermometer in the following manner.

The line 18 comprises a pipe having one end opening into the condensing chamber and its other end connected with a steel tube 35. The tube is firmly held upon the recorder casing by a lug 36 and adjacent said lug it is bent into a hollow spring 37 of Bourdon tube form. The spring is closed by a cap 38 which, in response to pressure variations, transmits the spring flexure to a pen 39 by way of a specially designed linkage. The latter compresses a link 40 pivoted on the cap 38; a bell crank 42 pivoted at 43 upon the casing; a link 44 pivotally interconnecting the link 40 and one arm of the bell crank; an arm 45 secured to the pen for oscillation therewith about the fixed pivot 30; and a link 46 pivotally interconnecting said arm 45 and the other arm of the bell crank.

The above described pressure links and arms are so proportioned and related that the recordations made by the pen 39 will bear a predetermined relationship to the corresponding temperature values. As may be seen by reference to the saturated ammonia tables, the temperature varies uniformly and takes a straight line when plotted, whereas the corresponding pressures vary non-uniformly to take a curved line. The described linkage is so designed as to record pressure in the same straight line relation that the temperature values are indicated. It should of course be understood that the desired relationship may be produced by specially designing either the temperature or pressure linkages, or both; and that the chart 34 must be properly marked to correspond with the linkage designs.

The linkage relationship is such that when the vapor in the condenser is pure the two pens will draw substantially coincident lines on the chart. This is because the total pressure in the condensing space is that of the vapor, which pressure corresponds with the indicated temperature. However, the presence of a foreign gas will affect the pressure indication, but not the temperature reading, and hence the pen points will separate to draw non-coincident lines when air is present. The degree of separation will show, at a glance, the amount of foreign gas present.

The particular chart illustrated in Figure 4 is designed for use with the modification of Figure 2, but serves to show in general a type of chart that may be used in all cases. It has temperature and pressure scales placed thereon, and the hours of day and night indicated. The lines 47 and 48 have been drawn thereon in two different colors by the pens 26 and 39 during actual operation of the apparatus of Figure 2. It should be understood that this chart might be dispensed with and the pair of pens replaced by a pair of pointers to give instantaneous readings. It further should be noted that any other factor than coincidence might be used to indicate 100% efficiency, so long as the factor satisfies the condition that the mechanical calculations may be quickly and easily read.

With reference now to Figure 2, there is illustrated another embodiment where the only modification consists in placing the thermometer bulb 19′ in the discharged cooling medium, and in redesigning the recorder R′ so that its linkage will produce coincidence of the pen points (at such times as the vapor is pure) in spite of the changed situs of the bulb. Under the usual conditions of condenser design, the temperature of the discharge passing out through the opening 13 should be about 4° to 8° below the temperature corresponding to the vacuum existing in the condenser. Using 4° for example, this 4° difference may be compensated for by forming the chart (see Figure 4) in such manner that each temperature value, which corresponds with a definite existing pressure, is marked 4° lower than that temperature value which would be found by reference to the saturated vapor tables; and so designing the recorder linkages that coincidence of the pens will result when no air is present. The compensation might also be obtained without alteration of the values given in the vapor tables, merely by designing the thermometer so that it will indicate those values which it would have if the bulb were inserted as in Figure 1 and if the 4° difference were properly maintained.

The arrangement of Figure 2 is preferred over that of Figure 1, for the reason that the recorder of the former is dependent not only upon the presence of foreign gas in the condenser, but also upon all other conditions which might affect the temperature of the discharged cooling medium. For example, such other conditions may consist of scaly tubes 9, dirt in the condenser, baffle 15 or division plate 12 carried away, insufficiency of cooling medium, or cooling medium injected at too high a temperature.

As previously stated, my invention is applicable to many other systems, where fluids are utilized under pressures and temperatures that may vary, for the purpose of indicating inefficiency or undesirable conditions.

Where, in my specification and claims, I refer to any particular fluid as a "gas", I wish it to be understood that this term may be synonomous with "vapor", and vice versa. Likewise, the term "pressure" is intended to include low and negative pressure (vacuum).

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:—

1. A method for determining the extent, if any, to which foreign gas is present in a volume of vapor, consisting in simultaneously and automatically recording the temperature and presure of the volume in selected units so related that the recordation reveals at a glance the presence and amount of any foreign gas in the vapor.

2. A method for locating causes of inefficiency in a pressure fluid apparatus, consisting in graphically indicating the total pressure of the fluid in selected units; and graphically indicating for purposes of quick and easy comparison, the temperature of the fluid in units corresponding to that pressure which the fluid, if pure, would have at the measured temperature.

3. A method for ascertaining the cause of any inefficiency of a vapor condensing system through which a cooling medium is circulated, said method consisting in mechanically indicating the pressure and temperature of the vapor in selected units so related that the indications reveal at a glance whether or not the temperature and pressure bear a predetermined relationship necessary to efficient operation of the condensing system.

4. In the method defined in claim 3, said indicated vapor temperature being obtained from the discharged coling medium by compensating for the normal temperature difference between said vapor and said discharged cooling medium.

5. In the method of claim 3, said indicated vapor temperature being obtained from the condensate formed in the condensing system.

6. A combination recording instrument for determining the presence or absence of foreign gas in a vapor, said instrument comprising a gauge designed to respond to the total vapor pressure and a device designed to respond to variations in the vapor temperature, and a chart associated with said gauge

and said device; said gauge and said device each having a marker and being designed to move said markers upon said chart through corresponding unit values upon variation of pressure or temperature, whereby the marker positions may be utilized for determining, merely by inspection of the chart, the amount of foreign gas present in the vapor at any given time.

7. An instrument comprising a thermometer having an element responsive to temperature within a gaseous space and designed to record such temperature in terms of that pressure which a particular vapor, known to be within said space, should have at said temperature; and a pressure-responsive device designed to record the actual total pressure within said space.

8. In combination with a condensing system having a vapor condensing chamber, a pressure-responsive device subjected to the total pressure existing within said space, and a thermometric device disposed for response to variations in temperature of the vapor being condensed, said device being designed to indicate in related terms which may be quickly compared to determine the operating efficiency of the system.

9. In the combination defined in claim 8, said devices being designed to indicate on a common scale and to show any discrepancies between each indicated pressure value and that value which the vapor, if pure, should have at the indicated temperature.

10. In the combination defined in claim 8, said thermometric device being subjected to the temperature of the discharged cooling medium of the condenser system.

11. In the combination defined in claim 8, said thermometric device having an element responsive to the temperature of the cooling medium discharged from the system, and said devices being designed to compensate for the temperature difference between said vapor and said discharged cooling medium.

In testimony whereof I affix my signature.

ROLAND G. REYNOLDSON.