United States Patent

Mandock et al.

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[54] **SINGLE-TRANSFORMER IGNITION SYSTEM FOR MULTIPLE GAS BURNERS**

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[52] **U.S. Cl.** **317/96,** 317/92, 431/255, 431/256

[51] **Int. Cl.** **F23g 3/00**

[58] **Field of Search** 317/96, 80, 81, 79, 92; 431/27, 67, 255, 256, 264

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[57] **ABSTRACT**

A simplified spark ignition system for industrial gas burners and the like wherein a single high-voltage transformer with "One Wire" feeder distribution through individual capacitance modules serves a multiplicity of burners and is operable in continuous duty from the usual utility power supply, requiring no rotary distributor or like mechanisms by reasons of achievement of a nominal switching action by use of low-level capacitance in the respective modules in series with the slight capacitance represented by the respective spark gaps and the breakdown impedance effect thereof as an ostensible diode effect to cause a chainlike sparking action with each gap firing at least once during each power cycle.

7 Claims, 3 Drawing Figures

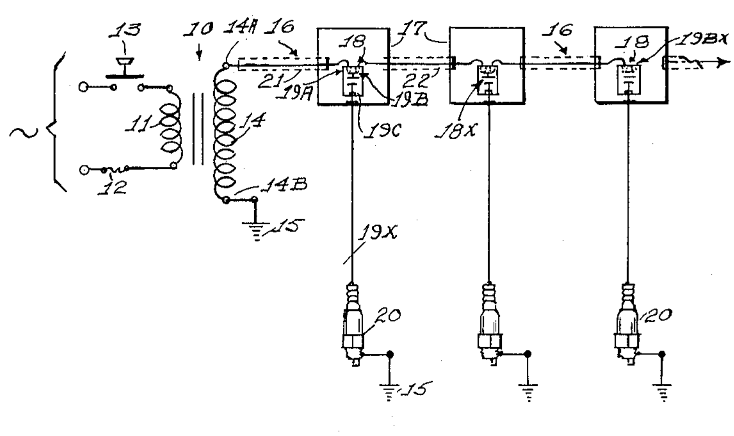


Fig. 1

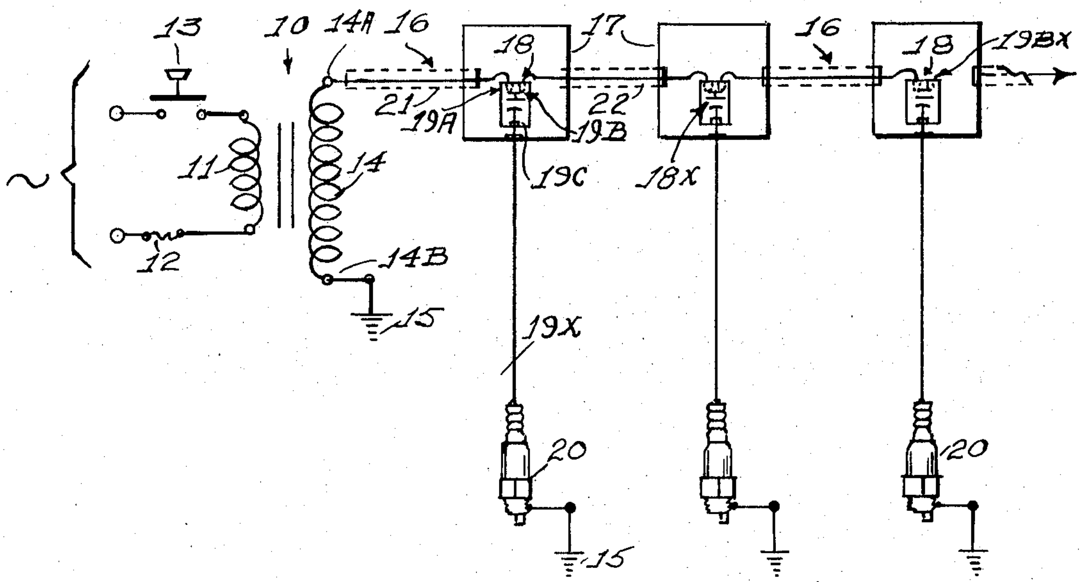


Fig. 2

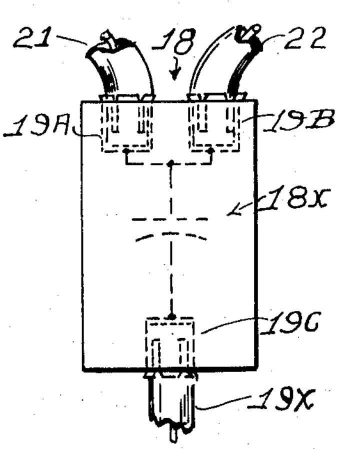
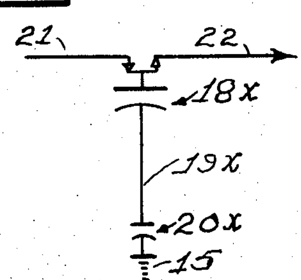


Fig. 2A



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SINGLE-TRANSFORMER IGNITION SYSTEM FOR MULTIPLE GAS BURNERS

Spark ignition systems heretofore feasible for safe operation with a large number of burners from a single transformer have commonly employed motor-driven distributor switches of one kind or another to apply the high-voltage sparking potential step by step to each kind of the ignition gaps in succession. This results in a time division in which there may be no spark at any burner during relatively gross intervals of as much as one-eighth of a second to 2 seconds. Such systems are relatively costly and may require auxiliary monitoring apparatus to ensure safety.

Still other systems employ individual ignition transformers for each burner with continuous sparking and achieve safer operation but at high equipment and maintenance cost.

In accordance with the present disclosures, a single high-voltage transformer can be economically and safely employed to serve as many as 40 or more burners without the use of mechanized distributing means or mandatory supervisory safety apparatus owing to the achievement of a nominal switching action and mutual triggering action by use of relatively low-level modular capacitance in series with each spark gap for each burner to constitute an ignition unit, and connecting all such units in parallel across the high-voltage feeder line in an approximately equal stray or distributed capacitance spacing, whereby the sparking does not occur simultaneously at all gaps, but all gaps are fired at least once in each power cycle where the aggregate of the R/C constants for each unit in the total array is kept within the period of one voltage or power cycle, the firing of one plug being considered to trigger the firing of another for reasons to appear as the following description proceeds in view of the annexed drawing in which:

FIG. 1 is a circuit diagram;

FIG. 2 is an enlarged detail of a capacitance module; and

FIG. 2A is a schematic diagram of the series-parallel capacitance pattern.

Referring to FIG. 1, the primary **11** of a special high-voltage transformer **10** is connected through suitable fuse or circuit breaker means **12** and an on-off master control switch means **13**, to the usual alternating current utility power source.

A secondary transformer winding producing a no-load peak voltage of about 5,000 volts has one of its terminals **14A** connected to a common return indicated as the ground **15**, and the other terminal **14B** connected by suitably insulated high-voltage distribution cable means **16** in series linkages extending from the transformer to the first and all subsequent burner stations in successive sections, each link terminating at each station in a junction box **17** housing a corresponding capacitor module **18** having certain structural features depicted to larger scale in FIG. **2**, and comprising a capacitance having a dielectric breakdown threshold at least equal to that of the transformer secondary in particulars noted hereafter.

The input or high-voltage side of each capacitor is adapted to connect with two links of the distribution cable, and is accordingly provided with internally connected linking "in-and-out" line terminals **19A**, **19B** at one end, preferably of the push-in type, there being another such terminal **19C** at the opposite or burner side of the module for connection with the appertaining spark plug by a length of high-tension feeder cable **19X** extended from the junction box to the ignition plug **20**.

Thus, one terminal of the transformer secondary connects to the common return or "ground" **15** while the remaining terminal **14A** thereof connects with the first capacitor module through a first link **21** of said high-tension distribution cable connecting with one of the pair of plug-in terminals **19A** at the first station, there being a succeeding linking cable section **22** plugged into the second terminal **19B** of said pair and extended for similar connection with one of the pair of input terminals of the capacitor module at the next station, and so on to the last station at which the second input terminal **19BX** is, however, left unconnected.

FIG. 2A illustrates the fact that each individual ignition unit consists of a modular capacitance **18X** and a gap or plug capacitance **20X** connected in series across the high-voltage feeder circuit comprising the linking cable sections **21**, **22** and common ground return **15** with the identical series-capacitance arrangements of the succeeding stations all paralleled across said feeder circuit and numbering in the recommended large installations about **30** stations or units, although many more might be added. For such an installation, we have found that the modular capacitance can be about 500 pfd., the gap capacitance being miniscule and regarded as a very high impedance until arcing or sparking occurs and the impedance drops very nearly to zero momentarily, with the effects alluded to hereafter. Preferably the gap or plug electrode will be set very wide, about one-eighth inch for the purpose of preventing buildup of bridging or short-circuiting accumulations of combustion and erosion products, and importantly also to limit the arcing current. In other respects, the ignition plugs may be conventional.

Thus, the transformer secondary normally (prior to sparking) sees all station units as very high impedances in parallel, the potential being highest across the plug electrodes since they have the lower value of capacitance across which the ionization builds up while the appertaining modular capacitors are charging only partially due to the limiting action of the gap impedance up to the instant of arcing-over, at which time the gap impedance suddenly drops to a very low value with a consequent sudden charging of the corresponding module capacitor, which can be expected to occur when the voltage on the ascending part of, say, the positive-going phase of the voltage sine wave reaches about 4,000 volts and continuing on up through the peak voltage and down the descending side of the curve to about 4,000 volts again, the same threshold voltages holding in the ensuing negative-going phase of the cycle but with reversed polarity, which has the effect of adding to the charges on the modular capacitors in a single cycle with the ultimate result that the effective voltage may be regarded as doubled.

In the foregoing voltage-doubling action, the spark gap acts analogously to a diode except that, because of the mentioned threshold limitations, before sufficient ionization is achieved to cause sparking, the voltages in only a portion of each half-cycle are effective and there is no true doubling in the conventional sense, but rather a marked voltage augmentation with substantial direct-current components in each half-cycle, so that for present purposes this action may be regarded as voltage doubling since such is the net effect in the high-voltage load presented to the transformer secondary, and this in turn is one of the critical parameters to be recognized in the successful operation of such a system, because ordinary transformers built to usual commercial standards will be destroyed in a matter of hours when their use is attempted in such an installation due usually to voltage breakdown in the secondary winding.

Thus the sudden change in impedance due to conduction and nonconduction across the gap effects a sort of switching action so that the appertaining modules are in effect switched out of the transformer circuit on extinction of the spark and the voltage rises again to act on another unit, and so on, the doubling effect appearing only in change from one half-cycle to the next, causing the 4,000-volt threshold to be reached much more rapidly in each cycle.

Another important factor in the successful operation of the system is the net loading effect due to the distributed capacity in the feeder circuit. As more and more modules are added this becomes significant when the number of burners served begins to approach 30 with long feeder leads, although this number is not to be understood as limiting, but rather as representative of the average large installation which will seldom exceed 40 units.

As an arbitrary convenience in accounting for the length of feed cable involved, stations are considered to be about 10 feet apart even though in fact they may actually be much closer together or separated at intervals of possibly 30 feet, and it will make no significant difference in the insulation requirements for the transformer until the feeder length begins to approach about 600 feet. In general, each additional module and linking feeder section multiplies the loading and breakdown voltage stress on the transformer due not only to impedance change, but most importantly to the voltage-doubling effect and the accompanying DC current components caused by the diodelike action at the spark gap. The distributed capacitance for an average large installation arbitrarily taken at 30 burners and an expected maximum not much exceeding 40 burners can be regarded as increasing at about only 10 to 11 pfd. per foot, whereas the reflected additive voltage due to the doubling effect rises at a rate of about 2,500 volts per 10 stations.

It is to be understood that flame rods may be used in place of conventional spark plugs where temperatures or locations require, the electrode spacing for rods usually being greater, possibly as much as one-fourth inch, to allow for warpage, the effective capacitance of the rod or plug gaps being practically the same, between 0.5 and 1 pfd., so that changes due to the choice or number of either kind of gap are insignificant in view of the ratio of about 500:1 with respect to the module capacitance.

Much shorter feeder cable leads are encountered, for instance on an automatic glass blowing machine having burner stations only four inches apart. On such an installation, the open-circuit or no-load secondary voltage of 5,000 volts RMS rises to about 7,000 volts for only **10** burners, and to over 9,000 volts for 30 burners. But with these very short leads the module capacitance of 500 pfd. is equally operative to ensure sparking of all igniters in a single cycle, as in another installation, for example, having linking sections 20 feet apart, in which case the secondary voltage can rise to nearly 11,000 volts RMS for only 12 burners. The peak secondary voltages reached in these examples will be well over 12,000 and 15,000 volts, respectively, which demonstrates the extraordinary voltage stress to which the transformer will be subjected.

Accordingly, the successful operation of the system will depend upon extraordinary insulation of the transformer windings, particularly the secondary which can be proportioned to the magnitude of the so-called voltage-doubling action in a ratio of about 3:1 over the threshold voltage, to which is added a safety margin making the ratio about 4:1. Thus, satisfactory operation can be had from a transformer in installations within the range of the illustrative examples affording a no-load secondary voltage of 5,000 volts with insulation capable of withstanding 20,000 volts, both RMS readings.

The modular capacitances must be designed to withstand the same voltage stresses, and in addition, must be protected against change or impairment of dielectric strength and insulation due to ambient conditions and foreign matter and employ a solid dielectric material and in turn are encapsulated in an Epoxy-type envelope in which are formed the linking and gap terminals described.

The simplicity and dependability of the system arises from the very rapid self-switching and timing action achieved in the series capacitance module-to-gap connection in each unit and the parallel connection of the units across the high-voltage line with an aggregate R/C factor adjusted to permit all stations to fire within one power cycle in dependence upon a sort of diode or gating action from the change in impedance across the spark gap from sparking to non-sparking state such that the modular capacitances tend to charge significantly in response to the decay and extinction of the spark across the appertaining gap and double or augment the effective high voltage on the feeder line, it being necessary, however, to protect the transformer by extraordinary insulation to enable it to withstand the excessive voltage rise which results from the doubling action, and to add for flexible use an operating and safety margin for a variable number of units.

The firing at each station tends to occur in a random succession which is apparently dependent in large measure upon ambient conditions, slight variations in component tolerances or parameters at each station, including ambient conditions from

one moment to another in the combustion chamber, fire pot or other burner. Some one plug will fire first followed successively by the others in a random order as the module capacitors are permitted or caused to charge by the abrupt local impedance changes at the gaps.

Such a system affords a time division for distribution of the ignition sparks which is a matter of a few milliseconds per station as contrasted with the gross time division found in motor-driven rotary-type distributors, and the relatively dangerous delay in sparking from station-to-station inherent in this method of utilizing a single ignition transformer.

We claim:

1. A spark ignition system for gas burners comprising, in combination with a single high-voltage transformer having an output potential of a given peak value to supply sparking voltage to a plurality of burner spark gaps, a high-voltage feeder circuit including a feeder cable from said transformer output extending in succession to each burner station and a common return for each gap for said output, a capacitor module for each station including a capacitance connected in series between said feeder cable and one terminal of the appertaining spark gap the remaining terminal of which connects with said common return, said gap presenting in its nonsparking state a high impedance in series with the module capacitance and becoming in effect a very low momentary impedance during sparking sufficient to permit the appertaining module capacitor to take on a substantial charge and in effect momentarily lower the applied voltage to other modules followed by abrupt cessation of such charging on extinction of the spark such that the voltage on the feeder line rises again to cause sparking at another gap in a repetitious chain action until all gaps have sparked during each output power cycle, said transformer having insulation to withstand the reflecting voltage increase from said gaps in a magnitude not less than twice said peak potential, and the total R/C constant for the plurality of capacitor modules and gaps timed such as to permit sparking at each gap during one such cycle.

2. Apparatus according to claim **1** further characterized in that each said module has interconnected in-and-out high-voltage terminals for use with said feeder cable, and said cable comprises a series of linking sections a first one of which leads from said transformer potential to a first module and a second and subsequent sections of which (except in a last section) lead from module to module, whereby a variable number of modules may be connected with said cable according to the number of burners to be served.

3. Apparatus according to claim **1** wherein said peak value is about 5,000 volts RMS and said insulation voltage magnitude is approximately four times said peak value.

4. Apparatus according to claim **3** wherein the frequency of the supply voltage is approximately 60 Hz., the module capacitances are substantially identical in value at about 500 pfd; and the gap capacitance is substantially uniform and between approximately 0.5 and 1 pfd. in value; said R/C time constant is of a value to permit at least one firing in succession for each of not less than 40 such ignition modules with said cable not more than 600 feet in length and a distributed capacitance of approximately 10 to 11 pfd. per foot.

5. A spark ignition system for gas burners and the like comprising: a plurality of spark gaps each serving a burner station; a capacitance module for each said station; a high-voltage transformer having a secondary winding supplying a high-tension sparking voltage output of predetermined peak value; means providing a common return conductive path from all said spark gaps to a first output terminal of said secondary winding; distribution cable means comprising a single-line feeder extending from a companion secondary output terminal to each of said burner stations; conductive means connecting each said module capacitance with said distribution cable means and said high voltage fed thereby, each said capacitance being connected in series relation with said voltage and the appertaining spark gap; said spark gaps each presenting an effective small capacitance of approximately the

same respective values and each said module capacitance affording substantially the same capacitance value as the others but of substantially greater magnitude than that of the spark gap; said secondary winding and each module capacitance being insulated against voltage breakdown under effective voltages which are in excess of the sum of said peak voltage and an aggregate reflected voltage produced in any power cycle by sparking action at the total number of stations during such cycle.

6. Apparatus according to claim **5** wherein the capacitance value of each module is such that the R/C constant afforded by the series connection thereof with the appertaining spark gap capacitance regarded as an impedance which decreases greatly in value during arcing, will permit a sufficient voltage to exist during each complete power cycle to fire all of said plugs during such cycle dependently upon a voltage multiplying effect resulting from the coaction with said series connection between each module capacitance and the appertaining gap.

7. In a spark ignition system having a multiplicity of spark plugs, a single-transformer continuous duty power means comprising a transformer having a high-voltage secondary winding supplying sparking a peak potential at approximately 7,000 volts, and insulation against voltage breakdown affording a breakdown level which is of an order in excess of twice said peak voltage, a capacitance module for each said spark plug having a capacitance substantially in excess of that normally existing across the gap of the spark plug and connected in series with said plug across the output of said secondary winding, said module capacitance having voltage breakdown insulation of not less than twice said peak voltage, and having a dielectric value which is substantially constant under ambient temperature, humidity and atmospheric conditions, and capable of withstanding breakdown under continuous peak voltages in excess of at least twice said peak value.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,649,876 Dated March 14, 1972

Inventors: Richard F. Mandock and
Ronald F. Plambeck

It is certified that error appears in the above-identified Letters Patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 7, for "step by step to each kind" read --step-by-step to each--; and at Column 6, line 5 (Claim 7), for "sparking a peak potential" read --sparking peak potential--.

Signed and sealed this 17th day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

UNITED STATES PATENT OFFICE

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