K8640(C-A)

A P I Publication 1702

PROCEEDINGS:

API RESEARCH CONFERENCE ON DISTILLATE FUEL COMBUSTION

JUNE 18-19, 1963

AMERICAN PETROLEUM INSTITUTE

需要全本请访问 www.ertongbook.com

Abstracts of the Technical Papers

ATOMIZATION

A Practical Ultrasonic Oil Burner

R. R. Perron, J. R. Swanton and E. S. Shanley
Arthur D. Little, Inc., Cambridge, Mass.

CP63-1

The ultrasonic atomizer has been brought to the stage of practical applicability by independent research activities at Esso Research and Engineering Company and at Arthur D. Little, Inc. Design of the atomizer proper is far enough advanced to permit the routine assembly of these units from readily available components and materials. Simple, one-tube power supplies have been perfected to drive the atomizer at about 55 kilocycles directly from 115-volt 60-cycle residential outlets.

Experimental burners have been operated on No. 2 fuel oil with high reliability and satisfactory combustion performance for many thousands of hours at flow rates from 0.2 gallon per hour to 0.7 gallon per hour. The atomizer also works perfectly well at lower flow rates. The ultrasonic atomizer appears to offer excellent potential for practical use, especially for low flow applications, such as water heaters and home space heaters.

Design details and operating data will be presented, together with visual demonstration of various burner configurations.

Optimization Studies on the Ultrasonic Burner

R. J. Lang
Esso Research & Engineering Co., Linden, N. J.

CP63-2

In building a practical ultrasonic oil burner which is capable of clean, efficient combustion, the design of the atomizer is extremely critical. The atomizer must provide the right spray pattern at reasonable power inputs and it must be stable in operation, long-lived, rugged, low in cost, and easily manufactured. Although the first stepped clamped horns made at Esso were simple and cheap, they gave poor combustion. Optimization studies were therefore made which uncovered a number of important design principles necessary for good burner performance.

Wide spray angles were found to give the best flames, but the large tip displacements necessary to obtain these angles caused a metal fatigue problem. Proper horn dimensions were found, however, which gave the spray characteristics required for good combustion without sacrificing atomizer life. Both the horn magnification ratio and longitudinal dimensions were optimized in this study. Also, several tip design and clamping features were found which are essential for stable operation and long life.

A burner head was designed to provide the correct air pattern to match the atomizer spray and also to protect the atomizer from damage by overheating at low firing rates. An optimized ultrasonic burner is now undergoing life tests at the severe operating conditions of 0.25 gph firing rate on 30 minute cycles, half time operating. Zero smoke is obtained with 10% CO_2 in the flue gas and the unit is operating well after 1250 hours.

Some Results From The Study of Ultrasonic and Electrostatic Atomization

R. L. Peskin and R. J. Raco
Rutgers University, New Brunswick, N. J.

CP63-3

Studied analytically are the effects of the parameters, frequency, amplitude, and flow rate on the expected drop size in ultrasonic atomization. Results are compared to known experimental data.

The governing equation for A.C. electrostatic atomization is derived and shown to be similar to the equation for ultrasonic atomization. The problem of the higher required voltage for A.C. atomization is discussed and the effects of frequency on A.C. atomization are studied. A method of diverting charged droplets from their trajectories along the electric field lines by use of magnetic fields is also considered.

A Photographic Method of Measuring the Drop Size Distribution of a Spray

S. M. DeCorso
Westinghouse Research and Development Center, Pittsburgh, Pa.

CP63-4

A technique is described which leads to increased accuracy for the photographic method of determining drop size. The unique feature of the method is the use of an optical system which produces Fresnel patterns around the drop images on the photograph. The width of the Fresnel fringes are used to determine depth of field over which drops must be counted.

Experimental and analytical verification of the fringe technique is given. Experimental apparatus and drop-counting procedure is described and typical drop size results are shown.

VAPORIZATION

Feasibility of a Vaporizing Burner for No. 2 Heating Oil

G. M. Hein and A. E. Weller
Battelle Memorial Institute, Columbus, Ohio

CP63-5

Studies combining experimental work and theoretical analysis were conducted to determine conditions needed for vaporization of No. 2 heating oil with minimum deposits. Results showed the desirability of: (1) low residence time of the fuel, made possible by high heat flux and/or thin liquid film, (2) prevention of continuous fuel fractionation, and (3) limitation of oxidative fuel degradation. Cyclic operation under these conditions, in combination with an air purge for oxidizing the deposits, was demonstrated in two types of high-temperature vaporizers. Deposit levels were less than 5 grams per 1000 gallons of fuel. Burning of the vapor was demonstrated in a close-coupled, swirl-stabilized burner.

To provide the needed conditions in a practical vaporizing burner, heat regeneration is necessary to reduce requirements for auxiliary electrical energy. The difficult task of regeneration in a high heat-flux system was solved by the use of "heat-flux transformers" in which heat is picked up at a relatively low heat flux and delivered to the fuel at high flux. The most promising method of achieving the regeneration with high flux was a liquid-lead thermosiphon loop.

An over-all concept for a vaporizing burner prototype was evolved, based on the demonstrated feasibility of the elements of vaporization, burning, and regeneration.

Precombustion Deposits

F. W. Rakowsky and G. H. Meguerian
American Oil Co., Whiting, Indiana

CP63-6

The processes governing deposit formation during vaporization of hydrocarbon mixtures in the presence of air have been studied by means of a continuous flow system. At about 750°F, paraffinic hydrocarbons produce very little deposits. The amount of deposits increases and passes through a maximum as the volume of aromatics in the mixture is increased. The level of this maximum varies mainly with the volatility of the aromatic. According to the mechanism suggested, paraffinic radicals produced by the interaction of paraffins and oxygen react with aromatic hydrocarbons to generate aromatic radicals. These relatively stable radicals then diffuse to the reactor wall, are adsorbed, and polymerize to produce deposits.

The best method of minimizing deposit build-up of this type is to prevent condensation. In vaporizing burners, vapors should be burned as soon as possible after vaporization and should not be allowed to contact cool surfaces.

DROPLET BURNING

The Ignition and Combustion of Drops in Sprays of No. 2 Heating Oil

B. J. Wood, W. A. Rosser, Jr., and H. Wise
Stanford Research Institute, Menlo Park, Calif.

CP63-7

Further experimental studies of the combustion characteristics of individual fuel droplets in the size range encountered in oil burners have been made. Specifically, ignition lags and preignition vaporization rates of single droplets of No. 2 heating oil have been measured under a variety of imposed conditions of temperature and gas environment. In addition, the effects of loading density, droplet size distribution, and total fuel-oxidizer ratio on the propagation velocity of flames in sprays of No. 2 heating oil have been determined.

The results of the experiments are reported in terms of their application to practical problems associated with atomizing-type burner design. For spray combustion in oil burners the role of droplet size distribution is discussed in terms of flame propagation velocity, flame dimensions, and luminosity. Numerical results of interest are presented in a nomograph which permits the rapid computation of the required maximum preheat-zone temperature and the spray residence time in the preheat zone to permit burner operation in the regime of blue-flame combustion.

Note: A complete report covering additional details of this research is in preparation and will be available as API Publication 1722.

COMBUSTION SYSTEM DESIGN

Turbulence and Recirculation as Combustion Parameters

R. Kamo, P. W. Cooper and C. W. Solbrig
IIT Research Institute, Chicago, Illinois

CP63-8

The results of an experimental investigation on No. 2 fuel-oil combustion are presented to illustrate the significance of turbulence and recirculation as combustion parameters affecting smoke and excess-air relationships. In a laboratory oil-burner system, critical values for smoke-free combustion have been determined for both parameters. When recirculation of combustion products exceeded the critical value, clean and flameless combustion was achieved. With addition of excess air, the critical recirculation ratio was reduced.

In order to evaluate the effects of each of the individual components present during recirculation, the effect of adding single gas components to the inlet air has been evaluated for nitrogen, carbon dioxide, carbon monoxide, oxygen, steam, and mixtures thereof. The critical mixture necessary for smoke-free, flameless combustion was determined for each. A mixing law was developed which relates the critical percentage of pure components to the critical percentage of mixtures of these components.

The Application of Available Research Results to the Design of Practical Oil Burners

W. A. Don—*Shell Research Ltd.*
W. Tipler—*Shell International Petroleum Co. Ltd., London*

CP63-9

While research into new principles and known processes is essential, the development of improved appliances should not await the completion of such fundamental investigations. The purpose of this paper is to indicate how experienced development engineers can take the results of a preliminary research study and apply them to the evolution of new equipment while their research colleagues continue their detailed studies. This approach is applied to the development of improved atomization and vaporization, more efficient air-fuel mixing, reduction of combustion noise, and the evolution of burner systems which depart from generally accepted designs by making the maximum use of the momenta of the fuel and air streams.

Several promising types of burners in use in the European domestic field are discussed. Also described is an entirely novel method of exhaust carbon measurement, suitable for use in the field.

EQUIPMENT STANDARDS

NOFI-Sponsored ASA Standards for Equipment Performance

A Panel Discussion arranged by the National Oil Fuel Institute

The American Standards Association has recently set up Sectional Committee Z-91 to adopt performance and installation standards for oil burners and oil-burning appliances. The National Oil Fuel Institute has been designated as sponsor of the standards activities and has recommended the establishment of a subcommittee for standards in specific areas.

In this panel discussion, C. E. Blome (*William Wallace Co.*) and M. J. Reed (*NOFI*), serving as Chairman and Secretary respectively of the ASA Z-91 Committee, will review the over-all objectives and scope of the new standards program and its significance for equipment manufacturers. In addition, the following subcommittee chairmen will outline plans for performance standards in their respective areas:

Oil Burners—W. J. Conlon, *Stewart-Warner Corp.*
Smoke Density Determination—F. R. Dunn, *Atlantic Refining Co.*
Fuel Nozzles—E. O. Olson, *Delavan Manufacturing Co.*
Furnaces—G. Peoples, *Lennox Industries.*
Boilers—J. I. Woodworth, *Institute of Boiler & Radiator Manufacturers.*
Water Heaters—M. L. Green, *Trageser Copper Works.*
Terminology—W. J. Smith, *Underwriters' Laboratories.*

API RESEARCH CONFERENCE ON DISTILLATE FUEL COMBUSTION

June 18-19, 1963 Pick-Congress Hotel, Chicago, Illinois

All Sessions: Avenue West Room

TUESDAY—JUNE 18

8:00 A.M. REGISTRATION—Avenue West Foyer

Conferees may also register June 17, from 8:00-10:30 p.m. in the Avenue West Foyer

9:00 A.M.—MORNING SESSION

Presiding: J. D. Heldman—*Shell Oil Co.*
Chairman, API Technical Advisory Group

Welcome: H. L. Moir—*Pure Oil Co.*
API Vice President Marketing

Atomization

Moderator: J. J. Donnelly—*Socony Mobil Laboratories*

A Practical Ultrasonic Oil Burner ---------- CP63-1
R. R. Perron, J. R. Swanton, and E. S. Shanley
A. D. Little, Inc.

Optimization Studies on the Ultrasonic Burner ---------- CP63-2
R. J. Lang—*Esso Research & Engineering Co.*

1:00 P.M.—AFTERNOON SESSION

Some Results From the Study of Ultrasonic and Electrostatic Atomization ---------- CP63-3
R. L. Peskin and R. Raco—*Rutgers University*

A Photographic Method of Measuring the Drop Size Distribution of a Spray ---------- CP63-4
S. M. DeCorso—*Westinghouse Research and Development Center*

Vaporization

Moderator: F. W. Rakowsky—*American Oil Co.*

Feasibility of a Vaporizing Burner for No. 2 Heating Oil -- CP63-5
G. M. Hein and A. E. Weller
Battelle Memorial Institute

Precombustion Deposits ---------- CP63-6
F. W. Rakowsky and G. H. Meguerian
American Oil Co.

General Discussion

ADJOURNMENT

5:30 P.M. RECEPTION

WEDNESDAY—JUNE 19

9:00 A.M. MORNING SESSION

Presiding: D. W. Locklin—*Battelle Memorial Institute*
Research Consultant to API
Oil-Burner Development Committee

Droplet Burning

Moderator: R. E. Paterson—*California Research Corp.*

The Ignition and Combustion of Drops in Sprays of No. 2 Heating Oil ---------- CP63-7
B. J. Wood, W. A. Rosser, Jr., and H. Wise
Stanford Research Institute

Combustion System Design

Moderator: C. W. Siegmund
Esso Research & Engineering Co.

Turbulence and Recirculation as Combustion Parameters ---------- CP63-8
R. Kamo, P. W. Cooper, and C. W. Solbrig
IIT Research Institute

The Application of Available Research Results to the Design of Practical Oil-Burners ---------- CP63-9
W. A. Don—*Shell Research Ltd. (London)*
W. Tipler— *Shell International Petroleum Co., Ltd.*

General Discussion
Concluding Remarks on the Research Papers
J. D. Heldman—Chairman, API Technical Advisory

1:30 P.M. AFTERNOON SESSION

Equipment Standards

Moderator: M. J. Reed—*Technical Director, National Oil Fuel Institute*

NOFI-Sponsored ASA Standards for Equipment Performance
—A Panel Discussion of Status and Plans
C. E. Blome, *William Wallace Co.*,
Chairman, ASA Sectional Committee Z91

NOFI Activities for Manufacturers
G. D. McDaniel—*President, National Oil Fuel Institute*

4:00 P.M. DISTRIBUTION OF CONFERENCE PROCEEDINGS

ADJOURNMENT

Conference Paper CP63-1

1963 API RESEARCH CONFERENCE ON DISTILLATE FUEL COMBUSTION

JUNE 18-19, 1963
CHICAGO, ILLINOIS

A PRACTICAL ULTRASONIC OIL BURNER

R. R. Perron, J. R. Swanton, and E. S. Shanley
ARTHUR D. LITTLE, INC.
Cambridge, Mass.

This paper may be published if credits are made to the authors, to their organization, and to the 1963 API Research Conference on Distillate Fuel Combustion.

AMERICAN PETROLEUM INSTITUTE
1271 Avenue of the Americas • New York 20, N. Y.



需要全本请访问 www.ertongbook.com

A PRACTICAL ULTRASONIC BURNER

Robert R. Perron, John R. Swanton, Edward S. Shanley
Arthur D. Little, Inc., Cambridge, Massachusetts

ABSTRACT

The ultrasonic atomizer has been brought to the stage of practical applicability by independent research activities at Esso Research and Engineering Company and at Arthur D. Little, Inc. Design of the atomizer proper is far enough advanced to permit the routine assembly of these units from readily available components and materials. Simple, one-tube power supplies have been perfected to drive the atomizer at about 60 kilocycles directly from 115-volt 60-cycle residential outlets.

Experimental burners have been operated on No. 2 fuel oil with high reliability and satisfactory combustion performance for many thousands of hours at flow rates from 0.2 gallon per hour to 0.5 gallon per hour. The atomizer also works well at lower flow rates. The ultrasonic atomizer appears to offer excellent potential for practical use, especially for low flow applications, such as water heaters and home space heaters.

Design details and operating data will be presented, together with visual demonstration of various burner configurations.

A PRACTICAL ULTRASONIC BURNER

Robert R. Perron, John R. Swanton, Edward S. Shanley
Arthur D. Little, Inc., Cambridge, Massachusetts

D12-26-62

I. INTRODUCTION

In 1961 API initiated at Arthur D. Little, Inc., a study of a new means of atomization as part of the API Research Program for Distillate Utilization. The work was reported at the API meeting in June of 1962. At that time, very promising results had been obtained with experimental ultrasonic atomizers, and interesting effects were being observed in the much more preliminary work with electrostatic atomization. Much of our effort since then has been devoted to the ultrasonic burner.

In a paper from the Esso Research and Engineering Company, Lang, Young, and Wilson (1) reported on an independent investigation of ultrasonic atomization. In February of 1963 the Esso group made its findings available to the API. The present report is based on both programs.

It is not necessary to review here the principles of ultrasonic atomization. An excellent treatment has been presented by R. L. Lang (2). Furthermore, the 1962 API Research Conference papers by Lang, Young, and Wilson (1) and by Doyle, Mokler, and Perron (3) provide basic discussions of the application of ultrasonic atomization to fuel oil burners. The purpose of the present paper is to report on progress during the past year, and to offer our prognostication for the future of this development.

II. THE DESIGN AND ASSEMBLY OF PRACTICAL ULTRASONIC ATOMIZERS

Ultrasonic atomization is based on the piezoelectric effect--literally pressure electricity. Certain natural materials such as quartz, tourmaline, rochelle salt, for example, generate electrical charge when stressed. Conversely, in an alternating field, such materials can be set into mechanical oscillation. In recent years, very powerful synthetic piezoelectric materials have become available at low cost. These materials have been responsible for a variety of new technical developments. The natural vibrational frequency of these ceramic-like materials is in the ultrasonic range. Thus, it is very convenient to generate ultrasonic energy by exciting these "crystals" at the appropriate frequency.

It has been known for some time that liquids can be atomized from a surface oscillating at ultrasonic frequency. However, effective atomization demands higher excursion than can be conveniently produced at the face of the piezoelectric materials. Fortunately, it is possible to employ mechanical amplification. This is accomplished by clamping the "crystal" to a solid bar of metal which is of such size and shape

as to form a resonant system with the "crystal." The metal bar can then be necked down in such a way as to increase the amplitude at the small end. In fact, the amplitude is increased by such a "horn" in inverse proportion to the ratio of the areas at the two ends. Amplification ratios as high as 20 to one are feasible. By this means it is possible to obtain excursions approaching 0.001 inch. This is adequate for good atomization. It has proven impractical to cement or adhere the crystal to the back of the amplifying horn. Consequently, it has been necessary to devise mechanical clamping means. These means depend upon the use of a resonant horn on either side of the crystal, with the clamp pressure applied at a point of minimum motion, i.e. a node. Two successful designs are illustrated in Appendix I of this report.

Electrical energy at the correct frequency is required to drive the piezoelectric crystal. The resonant frequency of our atomizer assembly is approximately 60-kilocycles. We have developed a very simple electronic circuit to supply the requisite power, about five watts, at 200-volts and 60-kilocycles directly from a standard 115-volt outlet. A major feature of the circuit is its ability to keep in exact step with the natural frequency of the atomizer assembly. This natural frequency changes with temperature and other environmental changes. Consequently, self regulation is a necessity for a practical device. The circuit developed for this purpose is illustrated in Appendix I.

Air handling in the experimental burners has been based on standard gun burner practice. However, it is necessary to take into account the relatively low radial momentum of the droplets from the ultrasonic atomizer. The air flow pattern must be such as to pick up and properly mix the relatively slow moving mist of oil droplets.

III. OPERATING CHARACTERISTICS AND RELIABILITY OF THE ULTRASONIC ATOMIZER

The ultrasonic atomizer accommodates a wide turn-down ratio. Atomization is controlled primarily by the amplitude and frequency at the working face of the horn. Within limits, the flow rate has only a moderate effect. Due to the thinner liquid film, lower flow rate tends toward finer droplets.

Peskin and Lawler (4) have discussed ultrasonic atomization from the standpoint of the instability of fluid interfaces. The mathematical expression of Mathieu for surface instability has been used by Peskin and Lawler to predict the size range of droplets from an ultrasonic atomizer. The results are in reasonable accord with experimental findings. Doyle, Mokler, and Perron (3) present a comparison between experimental findings and theoretical predictions on droplet-size distribution. Under conditions which are practical for burner operations, we have found that the mass median droplet size is about 100 microns.

Other investigators have reported similar findings. For example, Lang (2) reported experimental results in agreement with theoretical predictions based on the expected wave length of the capillary waves in the liquid film. Lang, Young, and Wilson (1) reported mass median droplet

P12-4-B2

size of about 120 microns at oil feed rates in the range of 0.4 to 0.6 gallon per hour, and somewhat smaller droplets at lower rates.

In general it can be said that the ultrasonic atomizer in its present form produces an oil spray similar to the spray from a high-pressure nozzle in both ignition and burning characteristics.

Our current atomizers have approximately 0.8 square inches of transducer surface (one-inch disk) and 0.052 square inch of atomizing surface at the working face. The tip excursion is approximately 0.0007 inch. This atomizer accommodates oil flow rates to 0.7 gallon per hour with satisfactory atomization. At higher rates it tends to spit and eject bursts of large droplets. Presumably larger flow rates could be accommodated on a larger atomizer, although attention would have to be paid to proper distribution of the oil on the working face. There is no particular lower flow limit. Atomization is satisfactory at any rate lower than about 0.7 gallon per hour.

Indicated life expectancy of the ultrasonic burner is high. The piezoelectric crystal will operate virtually indefinitely without degradation as long as it is not overheated. By passing the combustion air over the atomizer, and by providing heat shield as necessary, it has been found that the crystals can be held near enough room temperature to yield satisfactory life expectancies. At temperatures around 150°F it has been found that effective life may be reduced. At higher tempeature, 500°F for example, inactivation occurs at once. It is obviously necessary to keep the crystal cool.

Rather heavy stresses are set up in the ultrasonic horn, particularly at the point where the tip joins the shoulder. A generous fillet is indicated here to prevent stress cracking. The clamping means also must bear fairly heavy stress. For proper acoustic coupling, it is necessary to have the ceramic transducer and the aluminum horn surfaces flat to about 0.0005 inch, and to use clamping pressure on the order of 2000 pounds per square inch. Further, the clamping pressure must be maintained during and after the temperature cycling experienced by the atomizer in service. This may require special attention, such as the use of Belleville washers or the like in the clamping means.

The ultrasonic atomizer contains no small passages. The smallest passage is the feed hole in the working tip, and this can be 50 mils in diameter. Further, the passageways in the atomizer are self-cleaning due to the vibrating action. No indication of plugging has been observed in many thousands of hours of both continuous and intermittent operation. These findings lead to the expectation of very low service requirements.

In oil burners the best proof is in the burning. Long-term endurance studies have been conducted with both continuous and intermittent firing, in some cases for as long as 5000 hours without service or adjustment. We believe that we are now in a position to specify the design parameters to yield a life expectancy of more than 5000 operating hours.

These are:

A. Crystal temperature to be always below 150°F. It is to be emphasized that low-firing rate and intermittent operation constitute the most severe conditions, due to the limited and intermittent air flow under these conditions.

B. Horn designed to prevent undue stress concentration. In particular, the junction between shoulder and tip should have a generous fillet.

C. Clamping means strong enough to maintain clamping pressure of about 1000 to 2000 psi both during and subsequent to temperature cycling. This pressure is needed to maintain acoustic coupling between the piezoelectric crystal and the horn. It is necessary to use high-strength bolts and/or screws to avoid relaxation during operation.

D. Clamping means designed to avoid excessive pressure on crystal during temperature cycling. It has been demonstrated that differential expansion can lead to clamping pressure high enough to damage the crystal.

IV. ECONOMIC ASPECTS

Indications are that the ultrasonic burner will be economical to manufacture. The ceramic piezoelectric crystal, heart of the device, can be purchased for 80 cents or less in large quantities. The horn itself, of aluminum, can be produced at low cost on automatic machinery. Assembly is straightforward, although good alignment of the parts is necessary. The electronic driving circuit is estimated to cost about $5 to manufacture in quantity. The large passages in the ultrasonic burner can be supplied with oil at very low pressure. Consequently, a small motor can be used to supply oil and combustion air to the burner. The electrical gear for ignition, control, safety interlocks, and crystal drive can be integrated into a single package for maximum economy of manufacture.

Opportunity for saving in manufacturing cost is provided principally by the low pumping power equipment. This will permit the use of a small inexpensive motor and pump. There seem to be a number of forms which the pump and metering device might take. The current project has not been concerned with the optimization of this part of the system.

V. SUMMMARY AND PROGNOSIS FOR THE FUTURE

The API project at Arthur D. Little, Inc. was set up to study new means for the atomization of No. 2 fuel oil. In the course of the study it was found that ultrasonic atomization offered the most practical promise of any of the methods investigated. The development would not have been possible without the new synthetic piezoelectric materials,

which are vastly cheaper and more powerful than previously available materials such as quartz crystal. The keys to practical usefulness in fuel oil atomization were the successful development of stepped horns to give the required amplitude of vibration and the development of simple self-synchronizing electrical circuitry to supply the required high-frequency power to the piezoelectric material.

The next task is to interest prospective manufacturers in the ultrasonic burner. API is carrying out a vigorous program to accomplish this result. Design information on two different atomizers and power supplies is included as Appendix I of this report. Atomizers built with external flanges and bolts have been operated under combustion conditions for many thousands of hours. The integral flange and screw design incorporates both mechanical and electrical refinements but it has not yet been subjected to as much endurance testing.

API is now making arrangements for the construction of ultrasonic atomizers. These atomizers will be available for procurement by burner manufacturers for their own experimental use.

需要全本请访问 www.ertongbook.com

REFERENCES

1. Lang, R. J., Young, J. C. O'C., and Wilson, J. A., "An Ultrasonic Oil Burner," Proceedings: API Research Conference on Distillate Fuel Combustion, CP62-7 June 1962

2. Lang, R. J., "Ultrasonic Atomization of Liquids" The Journal of the Acoustical Society of America, 34, 6 (1962)

3. Doyle, A. W., Mokler, B. V., and Perron, R. R., "New Means of Fuel Atomization," Proceedings: API Research Conference on Distillate Fuel Combustion, CP62-1 June 1962

4. Peskin, R. L., and Lawler, J. P., "Results from Analytical Studies of Droplet Formation," Proceedings: API Research Conference on Distillate Fuel Combustion, CP62-2 June 1962

APPENDIX I

SCHEMATIC REPRESENTATION OF ULTRASONIC ATOMIZERS

The ultrasonic atomizer as now conceived consists of a piezo-electric transducer "crystal" which excites a mechanically resonant horn at an ultrasonic frequency. The horn, fabricated from solid aluminum, is designed to provide amplification of the vibrational motion of the tip. Oil is fed to the tip through an axial hole. Electrical power at the proper frequency is supplied from a self-resonant power supply.

Figure 1 is a schematic drawing of an atomizer using external clamping flanges and tie bolts. This design using one crystal requires an insulating washer between the horn and the clamping flange.

Figure 2 shows the driving circuit used to power the atomizer. This circuit supplies 60-kilocycle power at about 4.0 watts.

Figure 3 is a schematic drawing of an atomizer using integral flanges and two transducer crystals. This design permits the entire horn structure to operate at ground potential.

Figure 4 shows the driving circuit used to power the two crystal atomizer. This circuit supplies 60-kolocycle power at about 5.0 watts.

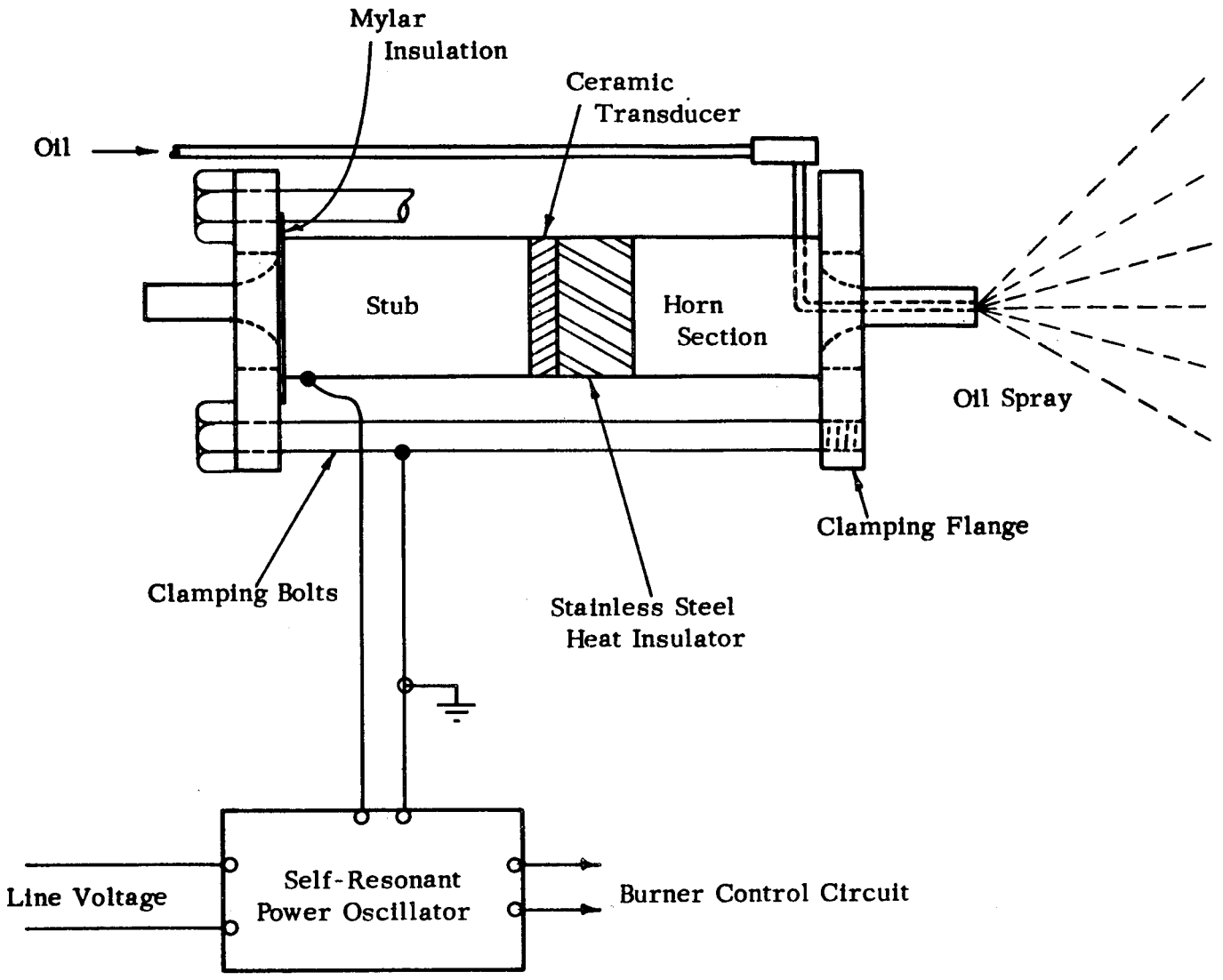
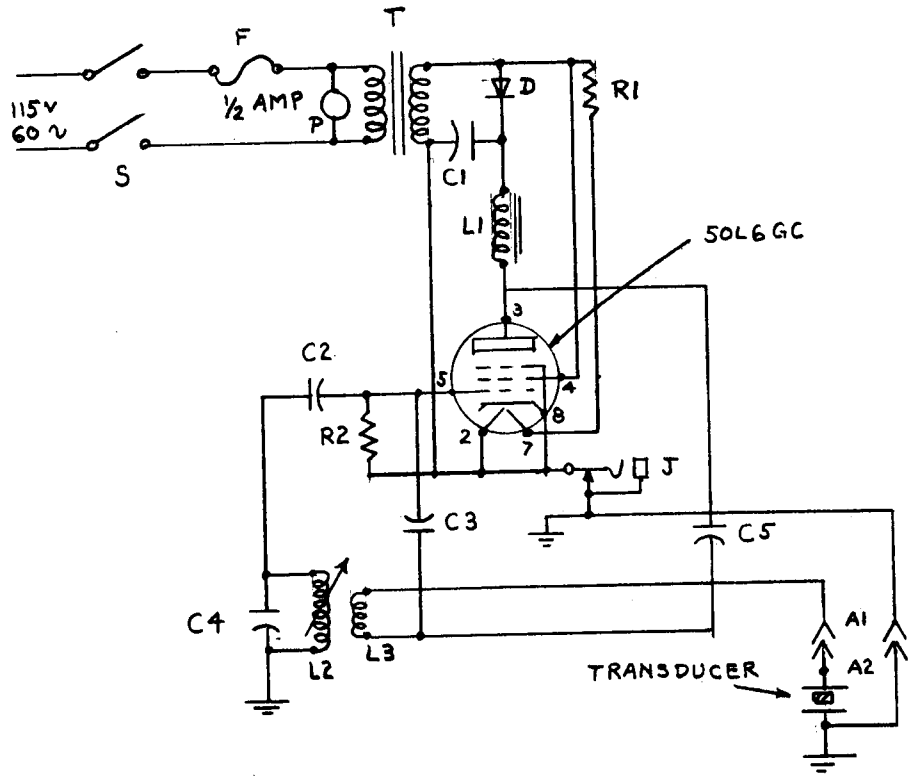


FIGURE 1 SINGLE CRYSTAL ATOMIZER



R1	450 OHM 10 W
R2	47K 1 W
C1	20 MF 200 V
C2	0.001 MF 500 V MICA
C3	33 MMF 500 V MICA
C4	0.0005 MF 200 V
C5	0.1 MF 600 V
T	TRANSFORMER, 115V TO 115V, 35 VA
L1	18 mh
L2	2-18 mh MILLER No. 6314, ADJ. ABOUT 10 mh
L3	10 TURNS No. 24 WIRE OVER L2
D	M-150 SARKES TARZIAN
F	FUSE HOLDER, LITTLEFUSE 342001
P	PILOT LIGHT, DIALCO 1010A3
S	DPST SWITCH, ARROW 20902-CX
A1	FEMALE CONNECTOR, AMPHENOL 80PC2F
A2	MALE CONNECTOR, AMPHENOL 80MC2M
	CHASSIS, BUD CB 1629
	CABINET, BUD CU 1098
J	JACK, SWITCHCRAFT C-12A

FIGURE 2 CIRCUIT SINGLE CRYSTAL ATOMIZER

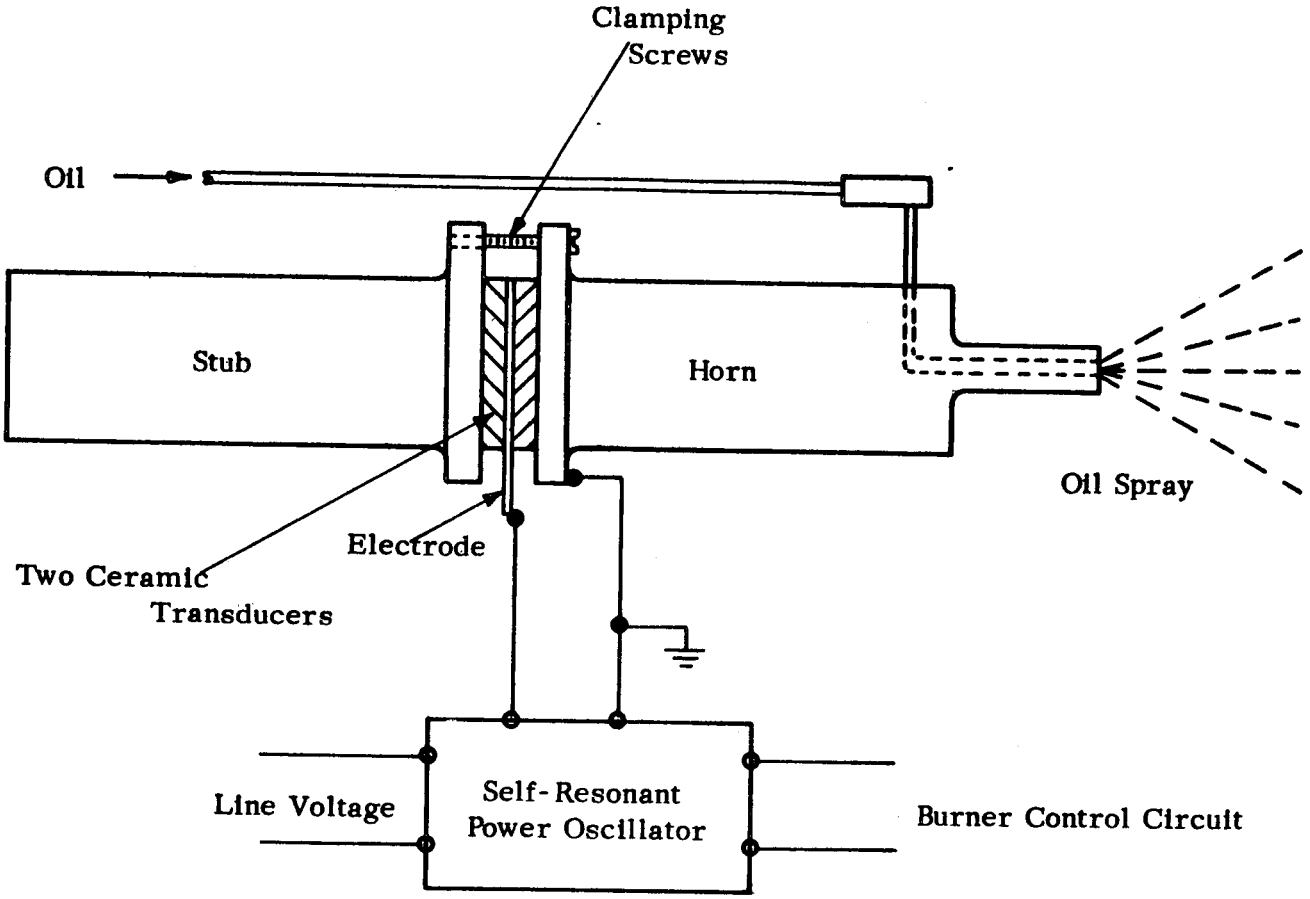


FIGURE 3 DOUBLE CRYSTAL ATOMIZER

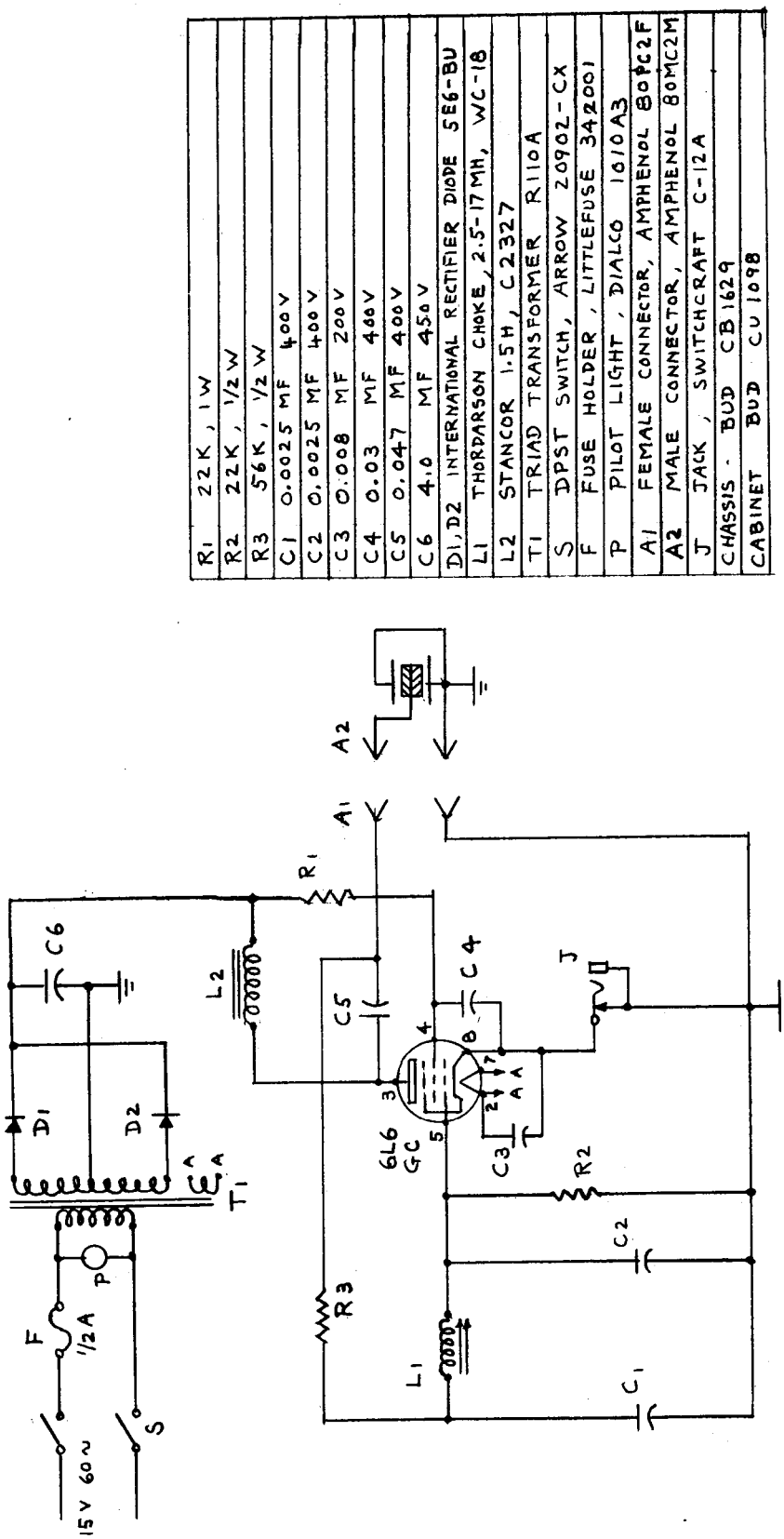


FIGURE 4 CIRCUIT DOUBLE CRYSTAL ATOMIZER

需要全本请访问 www.ertongbook.com