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Turecek et al.

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[54] **CAM FOR CONTROL OF COMBUSTION FUEL-TO-AIR RATIO**

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[52] **U.S. Cl.** .....**74/55,** 74/568 FS, 74/569

[51] **Int. Cl.**.....**F16h 53/00**

[58] **Field of Search** .....74/55, 568 FS, 569

[56] **References Cited**

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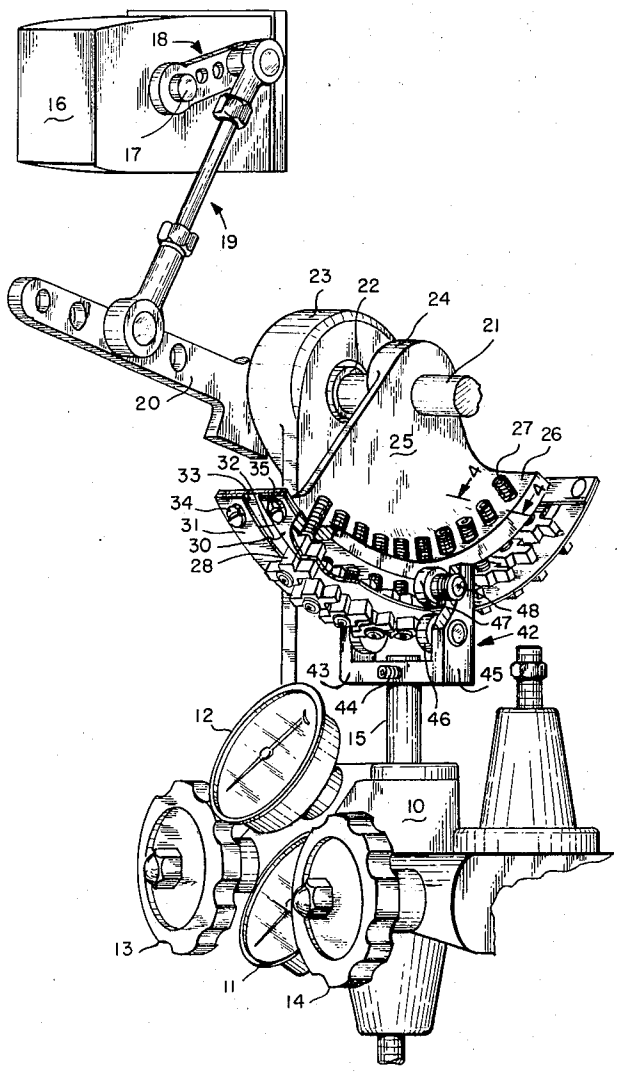
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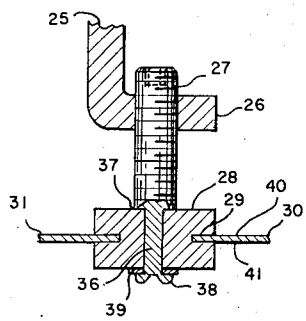
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[57] **ABSTRACT**

Optimum fuel-to-air ratio over the entire operating range of a boiler fuel burner is obtained by having a motor, which is driven in response to boiler temperature or pressure changes, operate a damper and fuel valves simultaneously. A cam and follower reposition the fuel valves coordinately with a directly driven damper. Means are provided to adjust the cam contour over its length so optimum fuel-to-air ratios prevail for all positions of the damper. The follower is positively engaged with the cam.

4 Claims, 4 Drawing Figures



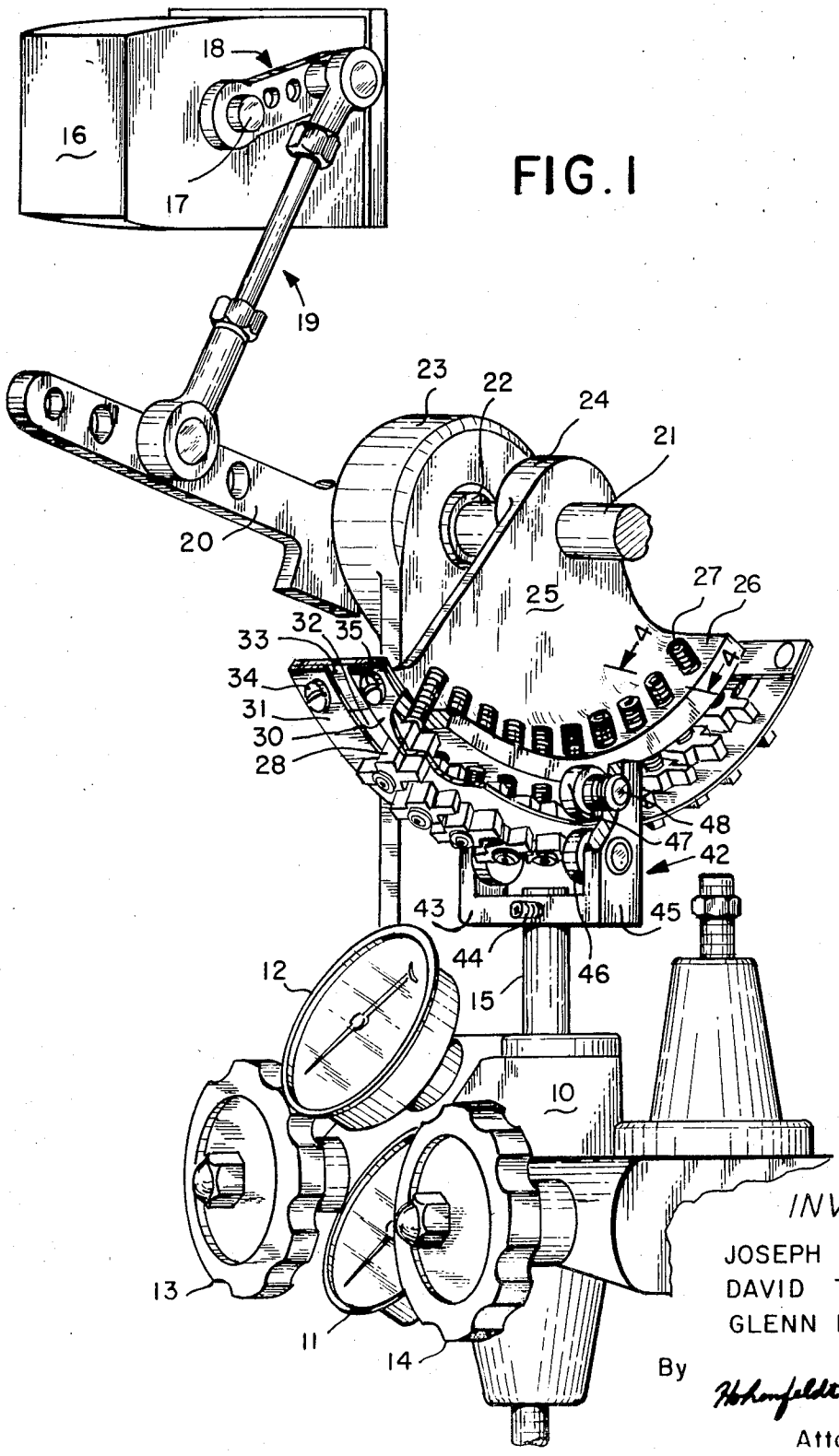


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SHEET 1 OF 2

FIG. 1



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FIG. 2

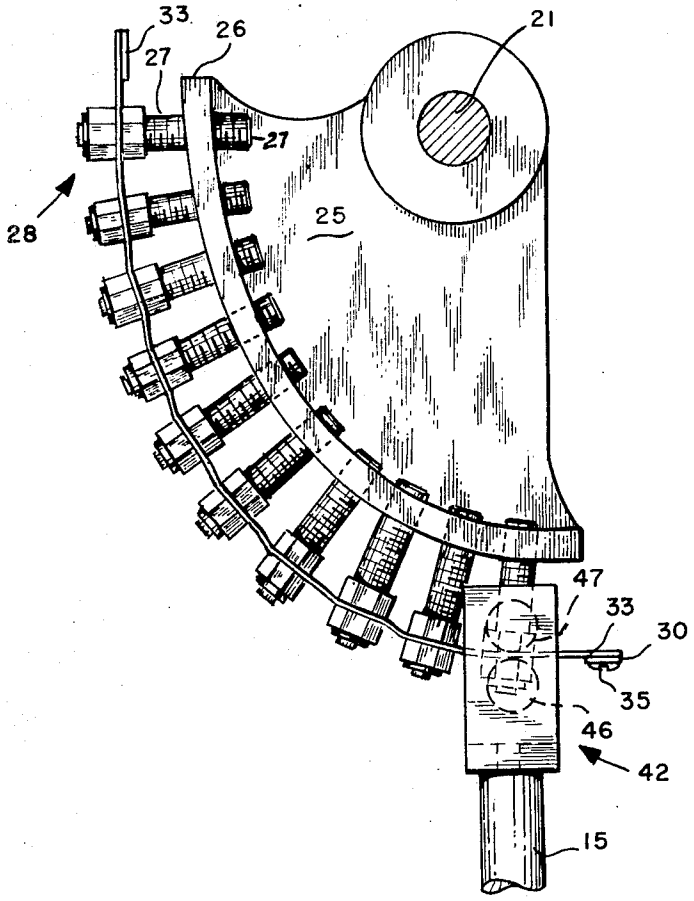


FIG. 3

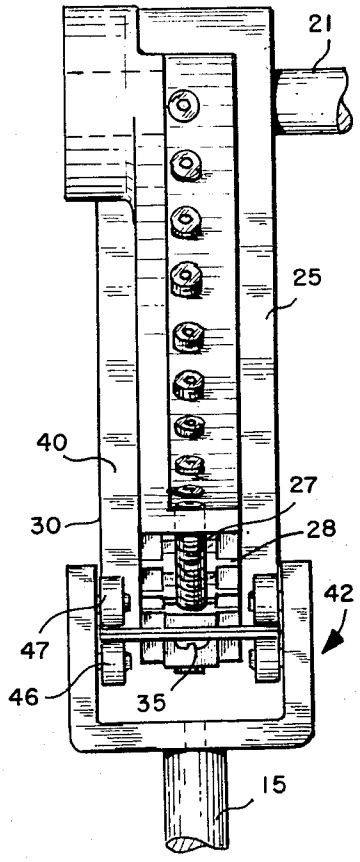
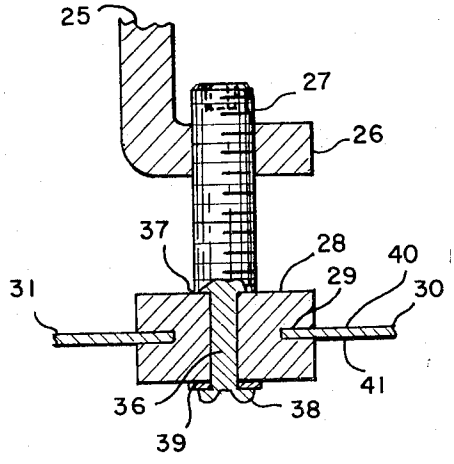


FIG. 4



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CAM FOR CONTROL OF COMBUSTION FUEL-TO-AIR RATIO

BACKGROUND OF THE INVENTION

In connection with boilers, furnaces and other heating devices it is necessary to modulate the fuel combustion rate in accordance with the temperature that is desired. In a gas or oil fired boiler, for example, a transducer or a sensor may produce a force or signal which corresponds with pressure or temperature of the water or steam, respectively. This signal may act through a control to actuate a damper motor which adjusts the amount of air and, simultaneously, the amount of fuel required for optimum combustion efficiency.

It has been common practice to adjust fuel flow by letting the damper motor drive a variable contour cam whose follower actuates the fuel valves. To provide a fuel flow which matches the air flow for obtaining efficient combustion at all discrete settings, flexibility must be built into the system because the flow characteristics of the fuel valves are substantially different than those of the air dampers. For instance, a specific movement of the air damper will provide an air flow which is not necessarily compatible with the fuel flow resulting from the corresponding movement of the fuel valve. Thus, an adjustable contour cam is required with flexibility to rotate or otherwise actuate the fuel valves more or less so that the fuel-to-air ratio can be properly established for any combustion rate.

Fuel valve control cams whose contour or profile may be varied over increments of the length of the cam surface have been used before. However, prior types have some disadvantages. If there was some resistance to return movement of the fuel control valve linkages there was often insufficient force in the cam follower spring for the follower to be held in contact with the cam. The result was that fuel flow rate to the burner was not always held in proper proportion to the air flow for optimum combustion efficiency.

SUMMARY OF THE INVENTION

An object of the present invention is to overcome the aforementioned and other disadvantages by providing a cam and follower assembly in which the cam contour or profile may be adjusted incrementally as desired and in which the follower is movably but positively engaged with the cam surface.

Another object is to provide a reliable, relatively simple and inexpensive fuel valve control cam assembly.

Briefly stated, one embodiment of the invention involves mounting an arcuate and bidirectionally movable cam segment on a journaled shaft for joint rotation with a link that is driven from the damper motor. The arcuate cam segment has a pair of nominally concentric spaced apart metal cam strips which are engaged in their intermediate gap by a plurality of circumferentially spaced cam strip engaging members or heads. Each member is supported from the arcuate segment by an adjusting screw which may be turned to adjust the member and the segment of the cam which it engages to a preselected distance from the center of rotation. The cam strips may then have a generally uniformly curved profile but with minor undulations at incremental zones where correcting adjustments are made.

The cam strips have exposed edge margins so that spaced rollers on a cam follower may positively engage the top and bottom surfaces of the cam strips and thereby be compelled to follow the cam strip contour and produce a positive linear driving force on the follower.

How the foregoing and other more specific objects are achieved will appear from time to time in the ensuing description of an embodiment of the invention taken in conjunction with the drawing.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a damper control motor and a fuel control valve which is operatively connected by the new cam assembly;

FIG. **2** is a side elevation view of the isolated cam and follower assembly;

FIG. **3** is an elevation view taken from the right side of the assembly shown in the preceding figure; and

FIG. **4** is a fragmentary vertical sectional view of the cam adjusting screw and affiliated parts.

DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. **1** illustrates one type of conventional boiler fuel valve assembly comprising a body **10**, some pressure gauges **11** and **12**, and a pair of manual flow control handles **13** and **14**. The rate at which fuel is metered through the valve depends, in this example, on linear movements of a valve stem **15**. Rotary valves are also used for metering gas or liquid fuels in some installations. On boilers that are adapted for switching from one type of fuel to another, both liquid and gas fuel valves may be present. The valves may be rotary or linear types and they may each be controlled by one of the new cam assemblies disclosed herein.

In the upper left of FIG. **1** the damper control motor **16** is illustrated. This motor responds to signals indicative of required changes in combustion conditions by rotation of its shaft **17**. The shaft has pinned on to it an arm **18** which has several adjusting holes and is pivotally connected to a turnbuckle link **19**. The turnbuckle link is pivotally connected to an arm **20** which is fixed on a jack shaft **21**. An air damper may be driven directly by arms from jack shaft **21**. The damper and arms are not shown.

The jack shaft is journaled for rotation in a bearing **22** which is secured in a bearing bracket **23**. Pinned on jack shaft **21** by means of a set screw **24** or other suitable means is a cam base **25** which has an arcuate longitudinally extending flange **26**. A plurality of socket-headed screws **27** extend radially through the flange **26**. These screws **27** are threaded in flange **26** in this embodiment.

Each screw **27** carries a cam contour adjusting head member **28** at the radially remote end of the screw. For brevity, these members will be called heads **28**. The heads **28** have slots **29** on their opposite sides. A thin strip of metal **30**, constituting a deformable-contour cam surface, is fitted into the corresponding slots **29** in a row on one side of the heads. There is another cam strip **31** similarly located in the row of slots on the other side of heads **28**. These parallel cam strips **30** and **31** have a gap **32** between them so that the center portion of heads **28** can pass between them. The ends of cam strips **30** and **31** are tied together by a strap **33** which is

secured to the cam strips by means of screws **34** and **35**. The cam strips **30** and **31** are similarly joined at both ends to fix them in parallel spaced relationship.

Because cam strips **30** and **31** are positively engaged by slots **29** in heads **28**, it should be evident that increments of the contour or profile of the deformable cam strips can be changed or shaped with undulations by variously adjusting the radial distance of the individual heads **28** from the cam base flange **26**. This is accomplished by turning adjusting screws **27** in or out with an Allen wrench. Thus, it is possible to establish the general contour of the cam strips **30** and **31** with adjusting screws **27** and it is also possible to change the profile of a selected cam strip length increment by adjusting a screw **27** in the head **28** that engages the cam strip where the profile of the increment is to be different than adjacent increments.

FIG. **4** shows how the contour adjusting screws **27** and the adjusting heads **28** are coupled. One may see that screw **27** has its diameter reduced in the region **36** so it passes through head **28** with a little clearance. The reduction in diameter results in formation of an annular shoulder **37** which prohibits axial upward movement of head **28**. The terminal end **38** and screw **27** is countersunk and flared for retaining the head **28**. A washer **39** is interposed between flared portion **38** and head **28** to provide a smooth bearing surface and to reduce friction when the screw is turned in the head to advance or retract it. Note in FIG. **4** that cam strips **30** and **31** extend laterally a considerable distance outside of slots **29** to provide upper and lower cam follower bearing surfaces **40** and **41** which are marked only on cam strip **30**.

Referring again to FIG. **1**, one may see that the cam follower which drives fuel valve stem **15** comprises a yoke which is generally designated **42**. The yoke has a cross member **43** and a set screw **44** for fastening to it valve stem **15**. The yoke also has a pair of spaced apart upstanding side members **45** each of which carries a pair of rollers **46** and **47**. The rollers are on stub shafts **48** the ends of which are threaded into side members **45**. The peripheral surfaces of the adjacent roller pairs of spaced apart a distance that is substantially equal to the thickness of cam strips **30** and **31**. Rollers **46** and **47**, therefore, follow faithfully all incremental undulations in the cam strip profiles. The fact that the cam strips are captured between the rollers results in follower **42** being driven forcibly in a vertical direction and the cam and follower cannot separate regardless of any resistance that may be offered by the valve stem **15** and its associated mechanism.

As stated earlier, arms extend from jack shaft **21** for operating the damper. The damper and arms are not shown since they are not part of the novel subject matter and it is only necessary to recognize for present purposes that the damper is repositioned in response to changing boiler conditions. The fuel valve is readjusted correspondingly at the same time. With the new cam assembly, the cam contour may be adjusted so that optimum fuel-to-air ratios are obtained for all settings of the damper.

The new positive drive cam assembly is subject to some structural modifications without departing from the principles of the invention. For instance, the structure shown in FIG. **4** may be made conversely. That is, the unthreaded portion **36** of the adjusting screws **27** may pass through a clearance hole in flange **26** and may be captured therein for rotation, and the threaded portion may be threadingly engaged with head **28**. Rotation of screw **27** will still actuate the head radially inwardly or outwardly to change the cam strip profile. The only limiting condition is that the cam follower must engage the cam surface by capturing it on both sides. The heads **28** could also be circularly slotted spools fastened to the screws **27** by turning and advancing and retracting with the screws.

In its broadest sense the invention requires a cam surface supporting member that is subject to rotational or translational movement relative to a follower which is positively engaged with the cam surface. The movement may be caused by any condition responsive force producing device. The cam surface is adapted for having increments of its length modified in profile so that the follower will move a distance which is disproportionate to the cam surface movement as may be predetermined at will. In the illustrative embodiment the cam surface members are mounted on heads which have individual adjusting screws extending from and threaded through an arcuate support. Various adjustable means other than screws could engage the heads and the heads or their equivalents could be replaced with other cam surface engaging means. Moreover, the cam surface could be mounted for translation in an angular plane in which case any incremental profile variations would still be transmitted to the follower.

Although a preferred embodiment of the invention has been described in detail, it will be understood that such description is to be considered illustrative rather than exclusive, for the invention may be variously embodied and is to be limited in scope only by interpretation of the claims which follow.

We claim:

1. A positive drive cam and follower assembly comprising:

a. a rotatable element having an arcuate part displaced radially from its axis of rotation,

b. a row of adjusting screw means extending radially from said arcuate part and turnable therein,

c. cam member supporting head means relatively rotatably mounted on said screw means,

d. a cam member, increments of which are deformable in a radial direction, said cam member having radially opposed surfaces and being engaged at spaced intervals by head means in a row, said head means having laterally extending slot means receiving said cam member and positively engaging each of said opposed cam surfaces, whereby selective rotation of the adjusting screw means will positively deform increments of said cam member correspondingly radially toward or away from said rotatable element, and

e. a cam follower means including spaced apart roller means in positive contact engagement respectively with said opposite surfaces of the cam member so that the follower means are compelled to move in radial directions corresponding with the profile of the cam member.

2. The invention set forth in claim **1** wherein:

a. said cam member comprises a pair of metal strips which are similarly contoured and spaced apart in parallelism with each other,

b. the slot means of said head means snugly engaging and supporting each of said strips at spaced intervals along their lengths.

3. The invention set forth in claim 2 wherein:

a. said metal strips comprising the cam member extend laterally outwardly in opposite directions from the slots to define the said opposed cam surfaces,

b. said follower means comprising yoke means on each side of which are pairs of roller means having parallel axes of rotation and which have their peripheries spaced part a distance that is substantially equal to the thickness of the metal strips, whereby the profile of the cam member strips that is presented continuously between the rollers due to cam rotation positively drives the cam follower means bidirectionally.

4. A cam assembly for closely coordinating the condition of the fuel and air flow control means of a burner wherein a cam follower means is driven in a positive manner bidirectionally to control the burner, comprising:

a. a rotatable element having an axially projecting curved flange means,

b. a row of adjusting screw means radially threaded through the flange means and having unthreaded portions at their ends remote from the flange means,

c. a head means disposed on each unthreaded portion of the screw means and means retaining the head means thereon but permitting rotation of the screw means therein for individually advancing or retracting said head means radially,

d. said head means each having opposed laterally extending slots defining parallel opposed rows of slots,

e. a pair of thin deformable continuous metal cam strips each having a corresponding edge spaced from and disposed in parallel with the other and with said edges being engaged in said respective rows of slots so that a cam profile is defined by the other edges of the strips which project from the slots, the said other edges having opposed cam surfaces,

f. a cam follower on which are mounted opposed pairs of rollers which have parallel axes of rotation, the peripheries of the rollers in a pair being spaced apart a distance that is substantially equal to the thickness of the cam strip, said roller peripheries in a pair being in contact simultaneously with said opposed cam surfaces for positively driving said follower linearly in correspondence with the cam profile increment that is presented between the rollers by rotation of the said rotatable element.

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