June 28, 1960 A. M. CADDELL 2,942,685

ROTARY TEMPERATURE-REDUCING EXHAUST SILENCER

Original Filed July 30, 1957 3 Sheets-Sheet 1

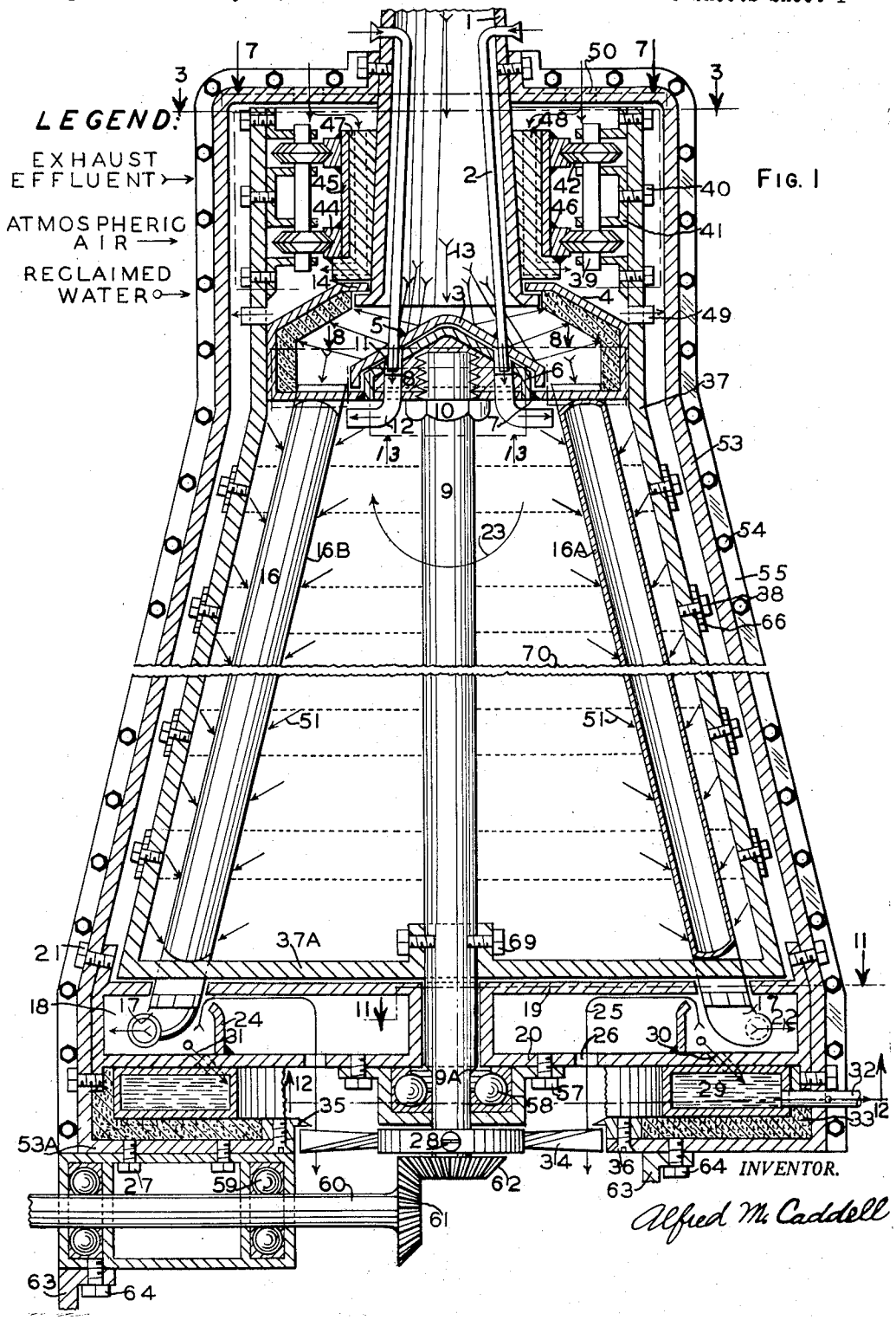



FIG. 1

INVENTOR.

Alfred M. Caddell

June 28, 1960 A. M. CADDELL 2,942,685

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FIG. 2

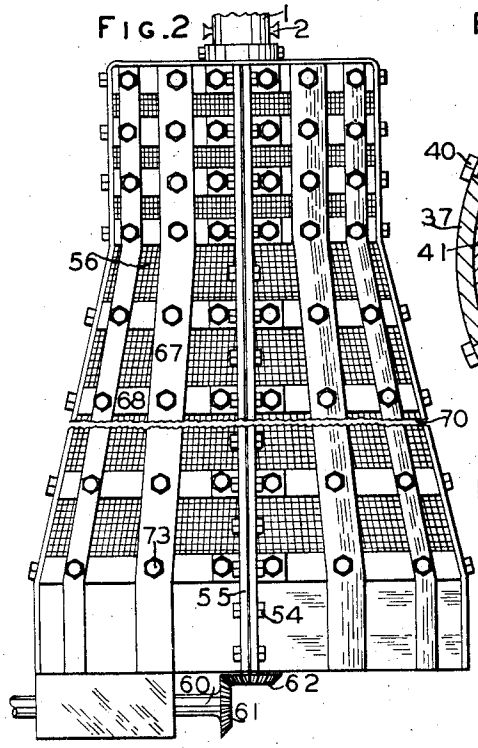



FIG. 3

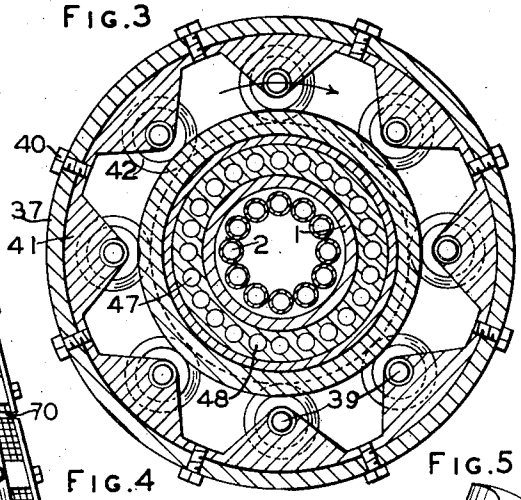



FIG. 4

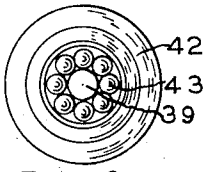



FIG. 5

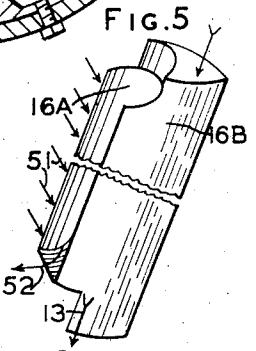



FIG. 6

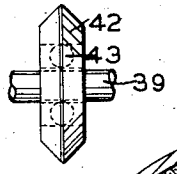



FIG. 7

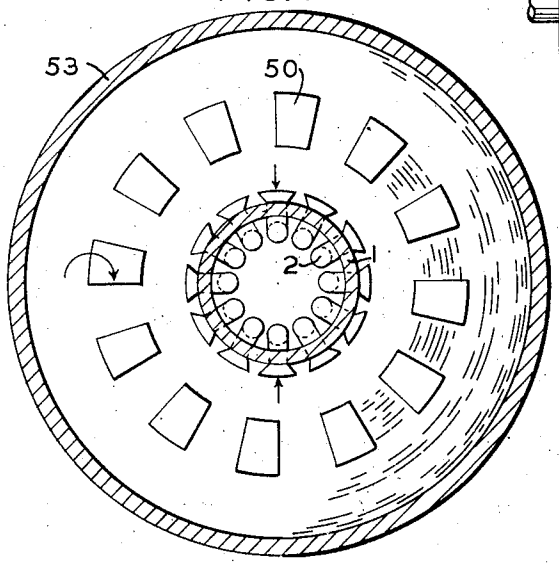
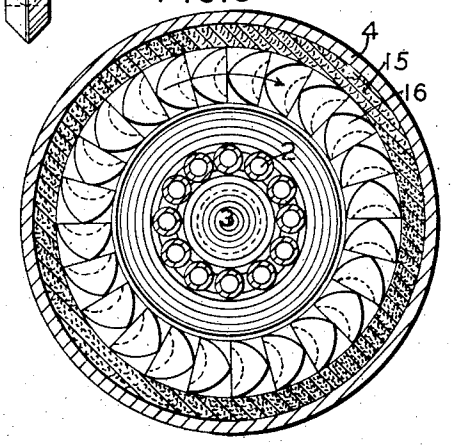



FIG. 8




INVENTOR.

Alfred M. Caddell

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FIG. 9

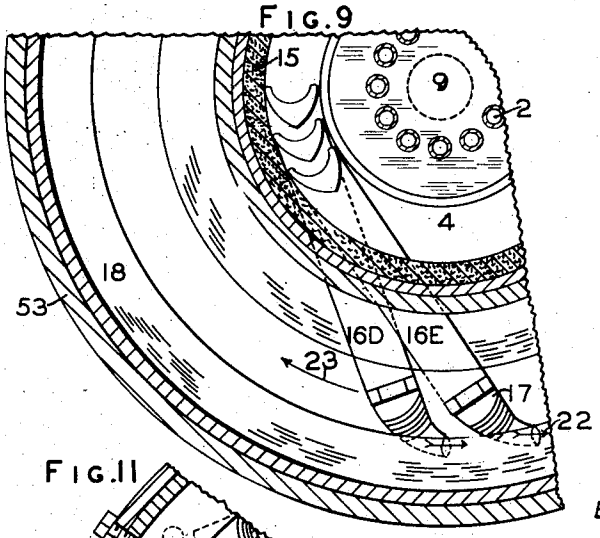



FIG. 10

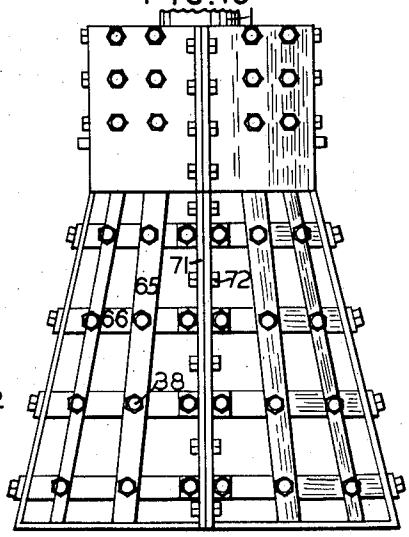



FIG. 11

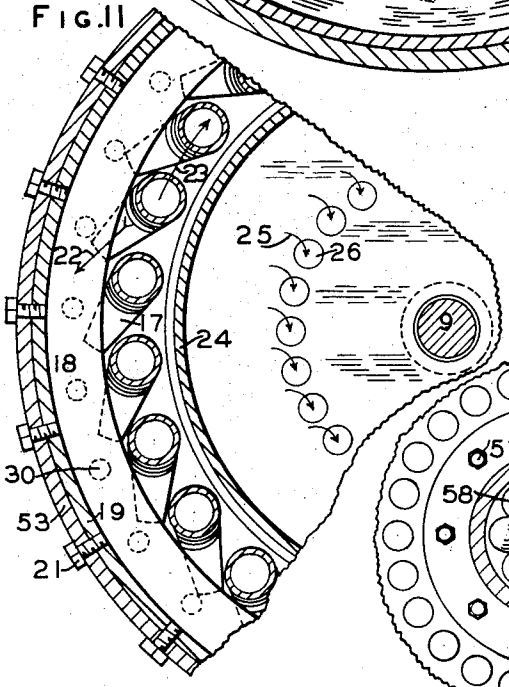



FIG. 12

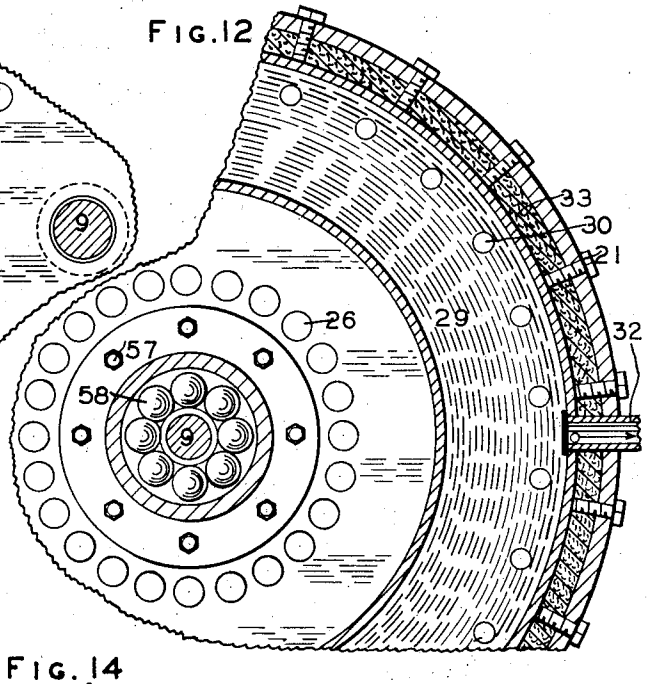



FIG. 13

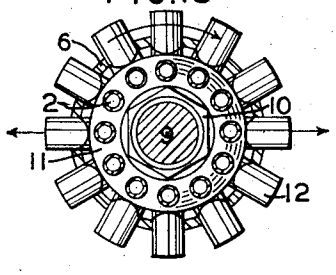
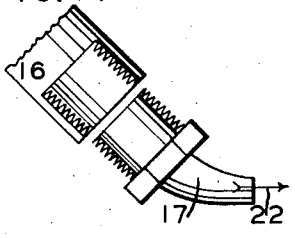



FIG. 14




INVENTOR.
Alfred M. Caddell

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2,942,685

# ROTARY TEMPERATURE-REDUCING EXHAUST SILENCER

Alfred M. Caddell, 1318 W. Hunting Park Ave., Philadelphia, Pa.

Continuation of application Ser. No. 675,107, July 30, 1957, which is a continuation-in-part of application Ser. No. 613,683, Oct. 3, 1956. This application May 20, 1959, Ser. No. 814,644

18 Claims. (Cl. 181—64)

Although the invention disclosed in application Serial No. 675,107 is not abandoned, the application itself now becomes abandoned upon the filing of this application, which is a continuation thereof. Serial No. 675,107 was a continuation-in-part of the then pending application entitled Evacuating Exhaust Silencer With Liquid Recovery Means, filed October 3, 1956, Serial No. 613,683, abandoned upon filing of Serial No. 675,107.

While the invention has to do with a rotary exhaust silencer per se, it is more than that. Through its ability to evacuate gas completely from a fire cylinder, it becomes a most valuable power booster for internal combustion engines. Moreover, it also serves in the capacity of a condenser for reclaiming water from exhaust gas and separating it for subsequent use. Or, if mounted on a steam engine, it would offer a practically instantaneous means for reclaiming water from steam exhaust and by so doing establish high vacua on the exhaust side of the engine which, in turn, would result in greater power output.

This silencer prevents the occurrence of exhaust noise by quickly reducing the temperature of the gas from the moment of its discharge from the engine's ports until its final discharge to atmosphere. The reduction of heat means the reduction of expansion pressure, thereby robbing the gas of its ability to create vacuum pockets in the air, the reactive closing of which by the pressure in the surrounding air causes noise. In contrast to a muffler, this device does not impede the flow of the gas; on the contrary, it accelerates its flow by means of the reduction-of-temperature process and the centrifugal throw imparted to the gas by the progressively increasing radii of the rotor's construction, which combination of factors causes a suction pull on the gas all the way back to the engine's cylinders.

The device is power-driven to set forces in motion for speedy withdrawal of the gas, but the power required is quite minimum; the power input is well compensated for by the following factors:

Exhaust gas is fed to the silencer under high pressure from the engine's cylinders. High peripheral rotor speed induces in the gas powerful centrifugal force which increases enormously with the increase in radius and peripheral velocity. Whereupon the gas discharges into a chamber through converging nozzles at the maximum radius of the rotor and in a direction opposite to that of the rotor's rotation, thereby setting up constant and powerful reactive drive. Simultaneously, after the liquid component of the gas is separated by condensation, the remaining constituent may be withdrawn from the chamber by a fan and discharged to atmosphere.

This reactive drive automatically reduces to a very considerable extent the input power required to maintain a strong suction pull on the gas. And the quicker and more thorough the withdrawal of gas from a fired cylinder the higher the compression ratio that can be employed, the greater the weight of the incoming fuel-air



charge and consequently the greater the power output per cylinder.

*Suction applied to the exhaust*

Experiments have shown that really outstanding engine performance can be had by applying suction to the exhaust. In one experiment, one pound of suction pressure applied at the end of an exhaust pipe, with five pounds of supercharger pressure on the intake side, packed more air into each cylinder than six pounds of supercharger pressure alone. One reason for this lay in the difference in temperature within the cylinders. The suction removed whatever lingering gas remained from the prior explosion, thus providing more space for the incoming charge. Translated into engine efficiency, a reduction in the number of cylinders or a smaller diametered cylinder bore will bring about a marked improvement in the horsepower-weight ratio and reflect noticeable savings in the consumption of fuel.

*Cost of muffling vs. evacuator silencing*

When it is realized that approximately 50 percent of the energy initially generated in the combustion chamber goes out with the exhaust, that 30 percent of the remaining energy is given up to muffling and the cooling system necessary to offset the retention of heat caused by muffling (impedance of flow), plus 10 percent lost to friction, it will be clear that only 10 percent is left for power. This has been abundantly proven by engine laboratories. Therefore, attaining exhaust silence via muffling comes at a high price. An oversize powerplant and an oversize cooling system become necessary to offset the aforesaid losses, and an oversize fuel bill also becomes part of the picture.

*Supercharging plus superevacuating*

Instead of having exhaust silence via muffling cost so much, it is proposed herein to put power directly into silencing—a minimum of power due to the supply of exhaust gas and the employment of compensatory reactive drive. In this connection, a comparison of superevacuating vs. supercharging becomes strikingly important.

In the supercharger field, 75 H.P. put into a blower to boost the intake pressure pays off in 300 additional H.P. put out by the engine. This is a 400 percent gain over the cost of the input power. In the exhaust evacuating field, experiments have shown that for every H.P. put directly into suction, five additional H.P. have been taken out—a 500 percent gain over the cost of the input power. This is without including compensatory or reactive drive. Therefore, with suction applied to the exhaust coincident with supercharging on the intake end, the push-pull effect on the engine would show up most appreciably in performance. Moreover, suction applied on the exhaust side would minimize the supercharger power required by preparing the cylinders to receive such added intake pressure at a reduced expense in power, which, in turn, would reflect in the size, weight and cost of the equipment.

*Exhausting directly to atmosphere*

Nothing, it would appear, could be more simple than permitting the gas to discharge directly to atmosphere. But aside from the unbearable din caused thereby, very harmful physical and acoustical effects associated with exhausting rob an engine of power.

In exhausting via open stacks, the speed of discharge is so fast—in aviation engines about 1,800 feet per second—that the exhaust puffs over-extend themselves, causing a partial vacuum to form in the wake of every discharge. These partial vacuums would be very helpful to power output if they could be preserved between dis-

charges, for they would assist in extracting more of the spent gas from a cylinder on every discharge, thus preparing the way for a heavier intake charge. But in open exhausting, with no means of preserving the aforesaid vacuums, there results an instananeous flashback of the gas, which can be seen by the aid of a stroboscope, to fill the voids the speed of the gas discharges create. Further, if a Pyrex glass pipe is employed and the engine exhausted in a room containing titanium tetrachloride smoke, smoke can be observed rushing up the pipe to fill the discharge-created voids. Whereupon the flashback gas meets head on with an oncoming discharge, thus causing above-normal back pressure. Such collisions translate into a power loss for every discharge, which losses are very costly and which emphasize the need to preserve the vacuums created by the exhaust for the benefit of the engine's output.

*Rotor speed required*

In this connection, it may be of interest to note the peripheral speed required by the rotor described herein to equal the velocity of gas discharging from an engine against static atmospheric pressure. This velocity is approximately 1,800 feet per second, taken at the engine's exhaust ports. To equal this speed and thus prevent the build-up of back pressure over and above that of static pressure, a rotor having a maximum diameter of 8 inches would have to rotate 860 r.p.m.'s, a 9-inch rotor 767 r.p.m.'s and a 10-inch only 694. Any rotational speed above these figures would yield a net gain in power output over the cost of power input, for the partial vacuums would be more thoroughly preserved and any added power requirement compensated for by the reactive drive created at the rotor's discharge end.

*Reclamation of water from the exhaust*

As above mentioned, this silencer reclaims water from exhaust gas. For every pound of hydrocarbon fuel burned in air, more than a pound of water may be obtained. Water is a by-product of the combustion process, the hydrogen in the fuel combining with part of the oxygen of the intake air to form water, while the carbon of the fuel ignites with other oxygen molecules to form, when combustion is complete, carbon dioxide. By quickly lowering the temperature of the gas as it flows through the silencer's tubes, the water is condensed out and gravitates into a tank while the residual carbon dioxide is removed by a fan for discharge to atmosphere. After filtering and treated chemically for the elimination of sulphuric acid traces, the water that was thus brought into being in the combustion chamber is readily available for injection into the same combustion chamber to increase the power output of the next incoming fuel-air charge.

*Reclamation of water from steam*

When used as a condenser, this device is capable of condensing water from steam in the shortest possible time, and at a minimum cost in weight and space. Compared to the bulky radiators of conventional design, which must be set out in the wind or in the slipstream of moving air to effect condensation, this device can be installed anywhere—even inside a vehicle—so long as air can be ducted to it. Upon rotation, it creates its own wind and dissipates heat to the air disturbed by such rotation.

It will undoubtedly be apparent, too, that the temperature-reducing means described herein may be put to use in fields other than internal combustion or steam engines; for example, quick condensation of vapors such as those that arise in petroleum refining; or to bring about new or more favorable reactions in chemical processes. Further advantages associated with this invention will become apparent as the herein disclosure proceeds.

In the drawings:

Fig. 1 is a cross-sectional view illustrating the silencer in detail with the exception of staggered mounting of the tubes, which feature is shown in Fig. 9.

Fig. 2 is a half-size exterior view of the silencer, featuring its outer lattice-type casing, the effluent conveying conduit at the top and the driving means at the bottom.

Fig. 3 is a view, looking from the top, of the multi-wheel bearing assembly employed for supporting the rotor on the effluent-entering end. The effluent-conveying conduit is centrally shown, as are also the pipes for conveying atmospheric air through the exhaust effluent to within close proximity of the concave faces of the tubes. This view is taken on the lines **3—3**, Fig. 1.

Fig. 4 is an enlarged side view of a bearing wheel of the multi-wheel assembly.

Fig. 5 is a three-quarter view of any one of the effluent-conveying-cooling tubes which, as indicated by the broken lines, may be of any length desired. These tubes are identified in Figs. 1 and 9 by the numeral **16**.

Fig. 6 is an end view of the bearing wheel shown in Fig. 4.

Fig. 7 is a view of the top of the casing, looking downward, taken on the lines **7—7**, Fig. 1, showing air-entering apertures therethrough and air-conveying pipes through the exhaust-conveying conduit.

Fig. 8 is a view of the receiving well, taken on lines **8—8**, Fig. 1, wherein is shown pipes conveying air through the structure that caps the pyramid formation, the effluent-entering ends of the air-cooling tubes, the sound-absorbing boundary wall of the well and its outer casing.

Fig. 9 is a fragmentary view, looking downward, of the tubular mounting, which may be read in conjunction with Fig. 8 which, in turn, shows the entrance ends of the tubes shown in cross section in Fig. 1. This figure (No. 9) shows the staggered, or trailing mounting of the tubes, such as those identified as **16D and 16E.**

Fig. 10 shows the solid wall and the lattice-type framework that comprise the walls of the rotor.

Fig. 11 is a partial view of the effluent-receiving chamber, taken on line **11—11**, Fig. 1, wherein is shown in dotted outline the water escape holes, nozzle ends of the effluent-conveying tubes, the water barrier for separating the residual gases from the water and the gas escape holes leading to the fan. For clearer reading, this figure should be superimposed on Fig. 12.

Fig. 12, taken on lines **12—12**, Fig. 1, shows the other side of the same gas-escape holes, ball bearing assembly supporting the shaft, the annular water reservoir, sound-absorbing media and the outer casing wall.

Fig. 13 is a view, looking upward, of air interchange means in the receiving well, taken on lines **13—13**, Fig. 1.

Fig. 14 is an exploded view of a tube's terminus and converging nozzle that screws into said terminus.

In several instances throughout this specification, the term "effluent" is used to direct attention to the fact that exhaust gas is a mixture of several gases and liquids, such as water condensed out of the gas and with it solutions of sulphuric and other acids as well as residuals arising from the use of additives in oil and fuel. However, the terms "gas" and "water" are mainly employed.

Exhaust gas as it comes from an internal combustion engine is accompanied by sound energies of many vibrational frequencies, some arising from the necessary tolerances between the pistons and their respective cylinders and the various components such as rings, valves, etc., all of which are set into sympathetic vibration by the intensities of the shocks attending combustion. In addition, as the exhaust gas passes through the varying restrictive passages created by opening and closing of the valves, eddy currents of extreme violence cause a wide range of high-frequency vibrations. These vibrations set the column of gas into equally violent commotion in the cylinder and throughout the entire exhaust system, so that when the gas passes into a manifold it is carrying sound

energies which, if not corrected, can have devastating effect upon engine performance. Some of these vibrational frequencies are susceptible of being nullified by resonance and some by absorption means.

As previously set forth, the purpose of this invention is to reduce the temperature of the gas as quickly as possible, thereby detracting from its ability to create vacuous pockets in the air and thus cause noise. Air-conveying pipes **2** are provided to assist in this effort. As shown in Figs. 1 and 7 and in cross section in Figs. 8, 9 and 13, these pipes pass through the walls of conduit **1**, turn therein at a right angle to become thoroughly exposed to the exhaust gas flowing therearound. The pipes then pass through stationary cap structure **3**, in well **4**, to which structure pipes **2** are secured, preferably by welding means, such as at **5**.

Located immediately beneath cap **3** is pyramidal formation **6**, which is made secure to the base wall of well **4**, being preferably welded thereto, as at **7**. This formation caps a filler casting **8**, into which shaft **9** is threadably engaged, being affixed thereto by locknut **10**. A circular travelway **11**, shown in Figs. 1 and 13, is provided in the pyramidal formation and filler casting to permit the rotating assembly to revolve around fixed pipes **2**. Inserted in casting **8** are an equal number of larger diametered pipes **12**, Figs. 1 and 13, which commence flush with circular travelway **11** to remove the air delivered by pipes **2**. The termini of pipes **12** have a greater radius than the inlet ends of pipes **2** and, therefore, upon high-speed rotation of the rotor assure a strong suction on the cooling air passing through these pipes. Coupled with the fact that tubes **12** discharge their air in close proximity to the concave air-attack sides **16A** of tubes **16**, a still stronger suction effect is thereby created and considerable heat extracted from the exhaust gas flowing through conduit **1** before it reaches well **4**. Pipes **21**, cap **3** and the cofunctioning pyramidal formation comprise an air interchange means between the fixed and the rotary components in well **4**.

This receiving well is comprised of a base wall and upright sides that turn inwardly at their tops and terminate in an overhang section, as at **14**, in close proximity to conduit **1**. This overhang section forms, in conjunction with the flanged base of the conduit, part of a labyrinth type of seal for providing a more or less leak-proof relation between the rotating well and the stationary conduit. The well is lined with a sound-deadening, or sound-absorbing material **15**, shown in Figs. 1, 8 and 9, to absorb sound energies from the gas.

Due to the fact that the walls comprising the well rotate at high speed in keeping with the other rotary parts of the silencer, the gas upon entering said well, as per arrow **13**, strikes the surface of cap **3** and is deflected both by the contour of the cap and by centrifugal force. Simultaneously, it is subdivided into streams as it passes into the conveying tubes **16** to undergo cooling. Fig. 8 shows the entrance ends of twenty-four tubes. Hence, instead of only one exhaust pipe, there are twenty-four tubes that attack air to which exhaust heat is surrendered convectively thereto. From the standpoint of acoustics, the sound energies are thrown violently against the upper and inner surfaces of sound-absorbing material **15** secured to the walls of the well in the interstices of which a wide range of sound energy frequencies are absorbed. For, under the principles governing the cancelling of sound energies, the most effective results are achieved when sound waves are deflected 180 degrees between their starting and receiving points, so that the conflict caused by the rebound, or reverberations, will cause the energies to kill each other off.

Tubes **16** and their progressively angular and trailing form of installation, as shown in Fig. 9, comprise the principal parts of this invention. These tubes are formed to execute the joint functions of conveying the exhaust effluent therethrough and simultaneously reducing its temperature by convection. As shown in Figs. 5, 8 and 9, the walls **16B** forming the effluent-conveying channel, have a streamlined contour which minimizes the resistance encountered in rotating the tubes through the air, while the air-attacking sides **16A** have a concave face for trapping air, as indicated by a plurality of arrows **51**, and conveying it through a major portion of the tube length. Fig. 5 shows how the air picked up and conveyed by these concave faces is thrown radially, as per arrow **52**, from their termini at the tubes' junction with radial plate **37A**, which comprises the base of the rotor frame **37**.

Cooling by convection is the most efficient of all air-cooling means. Air being a very poor conductor of heat, a hot surface will not radiate it efficiently to non-turbulent air. But when air is given rapid motion over and all around the same hot surface, each molecule of air will pick up heat and instantly reduce the temperature of the substance or surface to be cooled. And the faster the flow of air the quicker will heat be surrendered to it. All aviation radial engines are cooled via convection means, such as baffles directing air streams over and between cylinder fins.

The building up of rapidly moving streams of air in the concave faces of the tubes is purely a suction process. The greater the varied radius of construction, the greater the centrifugal throw of the air. This results in air rushing into the concave faces all along their sides to fill the demand of said greater radial throw. Hence, the hot effluent flowing inside the streamlined part of the tubes will surrender its heat to the fast-moving streams of air drawn into and discharged from the concave faces.

Effluent is both forced by pressure of high temperature from its source and is drawn through the streamlined part of the tubes by the aforesaid increased radial throw. While the effluent surrenders a major portion of its heat content—and therefore expansion pressure—to the air flowing in the concave faces and also across the tubes' streamlined sides, it acquires centrifugal pressure due to the aforesaid radii differential. This build-up of centrifugal pressure counterbalances the loss of the effluent's expansion pressure. In turn, this increase in centrifugal pressure prevents any part of the effluent from returning toward its source regardless of the strength of vacua produced in the exhaust system by the aforesaid suction means. Therefore, the partial vacuum that forms in the manifold just outside the engine's exhaust port in the wake of every exhaust will be preserved, and the speed of the next oncoming discharge will be increased to fill the partial vacuum. Due to the maintenance of this centrifugal throw while the other functions of the silencer are being accomplished—quick reduction of the effluent's temperature and condensation of the water vapor it carries—the constant preservation of such discharge-created vacuums will pay off handsomely in the form of continuous increased output of power and that, to repeat, is an outstanding objective of this invention.

Streamlined tubular part **16B** protrudes through radial plate **37A** which, as aforesaid, is a component of the rotor assembly. At this approximate position, the streamlined form of the tube assumes a rounded contour, such as that depicted in Fig. 14, into which rounded contour nozzles **17** are removably secured.

Reverting to the trailing form of tube installation previously mentioned, this type of mounting plays an important part in the functioning of said tubes. For, besides being mounted at progressively increasing radii from their beginnings in the well to their discharge ends within chamber **18**, the non-meridianal or trailing form of mounting, as shown by **16D** and **16E**, Fig. 9, permits installation of a greater length of tube for a given longitudinal dimension of a rotor. The length of a tube thus mounted is increased half as much again compared to a tube mounted in a strictly meridianal direction. Moreover, the greater the length of tube the greater the cool-

ing area and, consequently, for a given size rotor the more effective the reduction of gas temperature.

Another advantage of mounting the tubes trailingly lies in the fact that less power is consumed in attacking the air, the tubes slicing their way therethrough instead of directly attacking it. Moreover, discharge of the gas through nozzles **17** is facilitated due to the fact that said nozzles have a less angular degree of mounting relative to a strictly meridianal mounting for effecting the gas discharge. This non-meridianal mounting permits a practically straight-through flow of the gas from the well to the chamber. By aiding in the discharge flow of the gas, a stronger reactive drive effect will inevitably result.

Progressively radial and the trailing form of mounting of the tubes and the accompanying build-up of suction thus take on extreme importance in every aspect governing power output. For example, volumetric efficiency, on which power output greatly depends. For if all the dead gas is not exhausted from a cylinder—and it most assuredly is not in presently operated engines—that which lingers will seriously affect the qualitative and quantitative value of the incoming fuel-air charge. Being fully expanded, the remaining dead gas causes a volume-inflated, hot-oven reception for the fresh incoming charge, which expands instantly in keeping with such temperature, thus causing under-filling of the cylinder and a corresponding insufficiency of oxygen, which is the key to efficient combustion.

This shows up very pointedly from the standpoint of compression ratios. Whereas the swept volume of a cylinder indicates an 8 to 1 compression ratio, actually that cylinder, due to faulty exhausting as described, is operating at no more than a 4 to 1 compression ratio. Correction of this faulty exhausting is the key objective of this invention.

Chamber **18** is comprised of walls **19** and **20**, which are spaced from each other as shown in Fig. 1. These walls freely encompass shaft **9** and are removably affixed to the inner wall of casing **53** by screw bolts **21**. Fig. 1 shows a cross-sectional view of this chamber and Figs. 9 and 11 a top view. These latter views show positioning of nozzles **17** to discharge the effluent in a direction opposite to that of rotation, forked arrow **22** showing the general direction of effluent discharge while arrow **23** indicates the direction of rotation.

Barrier **24**, Figs. 1 and 11, is positioned within chamber **18** to effect separation of the residual gases and the water precipitated from the exhaust effluent as the temperature of the latter drops under 212 degrees F. Together with the gas, this water is thrown at high speed against the chamber's peripheral wall as indicated by arrow **22**, while the strictly gaseous component of the effluent travels out of the chamber as per arrow **25**, passing through apertures **26**, Figs. 1, 11 and 12, then through the blades of fan **34** mounted near the terminus of shaft **9** and being secured thereon by set screw **28**.

Upon being precipitated from the nozzles, the condensate gravitates into water reservoir **29** through slanting apertures **30**, which provide communication through the walls comprising the chamber and those comprising the reservoir. Arrows **31** indicate the general direction of flow of this water, while discharge pipe **32** is provided to convey this water from reservoir **29** to any desired destination.

Sound-proofing liners **33** are provided around this reservoir to minimize possible wall drumming or high-frequency sounds due to the velocity of discharge from the high peripheral speed rotor.

Just as the precipitate drop in temperature and the resonant and absorption means nullify sound energies in the effluent while ridding each cylinder of its spent gas, the character of the exhaust also becomes altered. Instead of intermittent discharges occurring with staccato accompaniments, as they would if the effluent were exhausting to atmosphere, such intermittency is rectified in the receiving well and the subdivision of the incoming effluent into a plurality of streams passing through the tubes. As a result, steady streams of effluent—not pulsations—issue from the discharge nozzles in the receiving chamber.

Fan **34** provides a suction pull upon the gaseous component of the effluent—mainly carbon dioxide—to maintain chamber **18** in a constantly relieved condition. Mounted on the bottom section **53A** of the casing wall and positioned adjacent the periphery of the fan is an annular plate **35**, held in position by bolts **36** which pass through casing **53**. This plate overhangs the blade tips to provide therefor a seal between the periphery of the fan and the innermost ends of **53A**, so that the full suction effect of the fan may be made available to evacuate the gas residuals from chamber **18**.

Fig. 10 shows an exterior view of the upper solid and the lower lattice-type frame of rotor **37**. This frame is of twin-half construction joinable together by flanges **71** and bolts **72** to facilitate assembly of the rotor. It is comprised of longitudinal and lateral members **65** and **66** respectively. Bolts **38** secure said members to each other. Radial plate **37A** is secured to shaft **9** by bolts **69**.

This silencer may function in either a longitudinal or laterally mounted position. If operated longitudinally, what may be regarded as the top of the rotor is held in accurate alignment by the multi-wheel bearing assembly, shown in cross section in Fig. 1 and by top view in Fig. 3. This assembly is secured to rotor wall **37** by screw bolts **40**. This wall supports brackets **41** which, in turn, carry individual knife-edge wheels **42** mounted on axles **39**. As shown in Figs. 4 and 6, these wheels have ball bearing assemblies **43** around their axles to assure anti-frictional rotation in grooved foundations **44** superimposed upon true-circle collar **45** and secured thereto by welding means, as at **46**.

To prevent expansion and possible distortion of collar **45**, due to its being contiguous to heat of the gas in the conduit, it is proposed to install between the plate and the conduit a high heat-resisting compound **47**, such as carbon graphite, which does not alter its form or composition under any temperature encountered in internal combustion engine operation. Collar **45** may be of any thickness desired to adequately carry grooved foundations **44**. A plurality of holes **48**, Figs. 1 and 3, extend longitudinally through carbon graphite **47** for the passage of atmospheric air therethrough. Air is drawn through these holes by suction induced by rotation of the rotor, tubes **49**, Figs. 1 and 10, extending through the walls thereof at a radius greater than that of the rotor walls and forcibly discharging said air therefrom. This air is made available by a plurality of apertures **50** in the top of outer casing wall **53**, Figs. 1 and 7. In addition to maintaining relatively cool atmospheric conditions within the area defined by the multi-wheel bearing assembly, the inflow of air extracts heat from grooved foundations **44** and true-circle collar **45**, thus assisting in maintaining accurate concentricity.

Outer casing **53** is of twin-half construction, the halves being affixed to each other by a plurality of bolts **54** extending through flange members **55**, Figs. 1 and 2. It is comprised of longitudinal and lateral members **67** and **68** respectively, which are secured to each other by screw bolts **73**. Like the rotor's lattice-type frame, the casing is open to atmosphere on its sides, carrying screening **56** to protect the whirling rotor inside. It also provides the main support for chamber **18** and the wall supporting reservoir **29**, which latter wall carries radial thrust bearing assembly **58**, secured thereto by bolts **57**. Shaft **9** has a shoulder **9A** adjacent its bottom extremity for riding on this bearing assembly, thus providing both radial and longitudinal support to the rotor.

Bottom wall **53A** of said casing serves as a base for securing thereto a ball bearing assembly **59**, through which assembly power-transmitting shaft **60** extends. This shaft

may connect to any source of power, none of which is shown, for providing turning effort to the rotor. Shaft **60** carries bevel gear **61** on its end for meshing with bevel gear **62**, which may be secured to shaft **9** by any conventional means, such as key and keyway, not shown.

The casing may be mounted on an engine block or other base by any suitable means, such as brackets **63**, to which the casing may be secured by bolts **64**. As indicated by broken lines **70**, the silencer may be constructed in any length desired.

Modifications may be made in the detailed structure of this silencer without departing from the scope of the appended claims.

Having described my invention, I claim:

1. An evacuating silencer having an air-cooled rotor for reducing the heat content of high-temperature, high-pressure effluent delivered therein by a conduit from an outside source, said rotor being driven by power from a source external thereto and by the discharge at the maximum radius thereof of said effluent in a direction opposite to that of the rotor's rotation, said silencer comprising an annular fabricated wall forming a casing for said rotor, said casing having a smaller compared to a larger diametered end and outwardly flared lattice-type side walls open to atmosphere, said rotor also having a smaller compared to a larger diametered end and being comprised of a solid annular wall, outwardly flared lattice-type side walls and a radially disposed plate serving as the base therefor, a shaft comprising an axis of said rotor, a heat-resisting substance positioned around said conduit, bearing assemblies for alignigly supporting said rotor at said smaller diametered end, walls including a bottom wall in said smaller end forming a sound-absorbing, effluent-receiving and distributing well, said shaft having one end secured in said bottom wall, said casing having a base and bearings mounted therein for supporting said shaft at its opposite end, a chamber formed in said base between radially disposed walls freely encompassing said shaft, the wall of the chamber nearest said well having an inner and an outer part spaced from each other to provide an annular travelway therebetween, a plurality of apertures formed through the bottom of said well and a like number of apertures having a radius greater than those of said well formed through said plate, tubes communicating with said effluent in said well and conveying it into said chamber via said travelway, said tubes having a concave face for attacking and centrifuging air during the rotor's rotation coincident with the passage of said effluent therethrough and a converging nozzle fitted to the end of each tube for discharging said effluent in said chamber in a direction opposite to that of the rotor's rotation.

2. In an evacuating silencer as described in claim 1, said conduit having a tapered formation commencing prior to the entry thereof into said silencer and continuing said formation to within the confines of said well at constantly increasing radii for furthering the expansion of said effluent therein, said conduit also serving as a stationary axis for the mounting of the smaller diametered end of said casing therearound.

3. In an evacuating silencer as described in claim 1, said sound-absorbing and effluent-receiving well being comprised of a base wall and annular upright walls forming the sides thereof, said sides abutting the inner surface of said solid wall and turning angularly inward to within close proximity of said conduit, an outwardly extending flange formed at the terminus of said conduit, said inwardly turning wall spatially overriding said flange to form thereat a labyrinth type of seal.

4. In an evacuating silencer as described in claim 1, the walls of said sound-absorbing and effluent-receiving well having an acoustic substance secured to the inner surfaces thereof for absorbing sound energies in said effluent, said substance terminating in close proximity to said conduit.

5. In an evacuating silencer as described in claim 1, a plurality of pipes for absorbing heat from said effluent prior to its delivery into said well, said pipes being open to atmosphere and extending through the walls of said conduit into said high-temperature effluent, a pyramidal construction formed in the base wall of said well, an annular travelway provided in the top of said construction and a plurality of holes extending from said travelway through said base wall, a stationary plate comprising a hood spaced from said construction for deflecting effluent delivered by said conduit against said sound-absorbing walls, said heat-absorbing pipes protruding through said hood and being made secure thereto, a plurality of short pipes installed in said holes, said latter pipes having a right-angular turn beneath said well for discharging into the area swept by the concave faces of said effluent-distributing tubes the air conveyed by the first-mentioned pipes through the effluent being delivered by said conduit to said well.

6. In an evacuating silencer as described in claim 1, said heat-resisting substance conforming on the inner side thereof to the conduit's tapered formation and having on its outer side a wall paralleling the center line of said conduit, a plurality of holes through said element adjacent the wall of said conduit, said holes turning right angularly near the base thereof, a plurality of apertures in the top wall of said casing and a plurality of openings in the wall of said rotor in its smaller diametered end, a like number of tubes protruding outwardly from said openings for creating during rotation suction of air from atmosphere through said top wall apertures, through said heat-resisting element and discharging it at a radius greater than that of said top wall apertures.

7. In an evacuating silencer as described in claim 1, said effluent-conveying tubes having an advancing face and a back trailing, relative to the direction of the rotor's rotation, toward a knife-edge to form a streamlined construction for minimizing vacuum drag during said rotation, the side of the tubes advancing in the direction of rotation having a concave face that comprises a forward wall for said channel, said faces being formed on said tubes between the base wall of said well and the top of the radial plate comprising the base of said rotor, said faces drawing air therewithin in increasing volume and velocity as mounting of the tubes radially increases and discharging it at the maximum radius of said mounting at the top of said plate simultaneously with the passage of said effluent through said streamlined construction.

8. In an evacuating silencer as described in claim 1, said effluent-conveying tubes being mounted between said well and said chamber in a non-meridianal pattern, the discharge ends of said tubes being secured in the base of said rotor in a trailing direction relative to a true meridianal mounting and relative to the direction of the rotor's rotation.

9. An evacuating silencer having a casing comprised of walls open to atmosphere and a rotor mounted therein for rotation, said rotor having walls exposed to atmosphere for reducing by convection during the rotor's rotation the heat content of high-temperature effluent, a conduit terminating within the confines of said rotor for conveying said effluent thereto from an outside source, said rotor having an intake and a discharge end and a radius greater at its discharge end than at its intake end, said rotor being driven by power from an outside source and by the discharge of said effluent therefrom in a direction opposite to that of the rotor's rotation, said rotor comprising an effluent-receiving and distributing well formed by walls adjacent the terminus of said conduit, a chamber formed by walls in the base of said casing, a plurality of tubes secured in the base of said well and flaring outwardly and downwardly therefrom for conveying said effluent from said well to said chamber and si-

multaneously creating a relative wind over the surfaces of and around said tubes during the rotor's rotation, nozzles fitted to the ends of said tubes for revolving within said chamber, said nozzles being turned at an angle relative to the mounting of said tubes for discharging said effluent in a direction opposite to that of the rotor's rotation.

10. An evacuating silencer for reducing the heat content of high-temperature effluent comprised essentially of carbon dioxide gas and water in vapor form and conveyed therein under pressure by a conduit from an outside source, the combination comprising a casing having walls open to atmosphere on its sides, a frusto-conical rotor mounted around a shaft for rotation in said casing, said rotor having a construction paralleling the contour of said casing and likewise being exposed to atmosphere, said rotor being rotated by power from an outside source and by the discharge of said effluent at the maximum radius of said rotor in a direction opposite to that of the rotor's rotation, a well formed by walls in said rotor adjacent the terminus of said conduit for receiving said effluent and distributing it therefrom, a radially-mounted plate having a radius greater than that of said well and comprising the base of said rotor, a receiving chamber formed by walls in the base of said casing, the chamber wall nearest said well having an inner and an outer section spaced from each other to provide an annular travelway therebetween, a plurality of effluent-conveying tubes rotating in free air simultaneously with the passage of said effluent therethrough, said tubes having communication with said effluent in said well, extending through the rotor's base plate at said maximum radius and entering said chamber via said travelway, converging nozzles fitted to the termini of said tubes, said nozzles having an angular bend for discharging said effluent in said chamber in a direction opposite to that of the rotor's rotation and a barrier wall mounted in said chamber for separating water condensate from said gas.

11. In an evacuating silencer as described in claim 10, said chamber being comprised of circumferential walls that abut the inner surface of said casing wall, said chamber walls extending inwardly to freely encompass said shaft, said barrier wall being positioned in close proximity to said nozzles, said barrier having a top curving toward said nozzles, a space between said top and the inner surface of the top wall of said chamber, said space providing an escape means for said carbon dioxide gas from said chamber.

12. In an evacuating silencer as described in claim 9, sound-absorbing substance secured to the walls of said chamber for absorbing sound energies that develop incident to the discharge of said effluent in said chamber.

13. In an evacuating silencer as described in claim 10, a series of apertures formed through the base wall of said chamber for the passage therethrough of water condensed from said gas, an annular reservoir formed contiguous to said base wall for receiving said water and a drain tube leading therefrom for conveying said water to an outside destination.

14. In an evacuating silencer as described in claim 10, openings provided in the base wall of said chamber for the release therethrough of carbon dioxide gas separated from said effluent, a suction fan mounted on said shaft for aiding in the removal of said gas from said chamber and dispelling it to atmosphere.

15. In an evacuating silencer as described in claim 1, said heat-resisting substance having non-expansive qualities in the presence of high heat, said substance being encompassed by a non-expansible true-circle collar, grooved trackways mounted on said collar for the rotation of bearing assemblies therein and therearound, said trackways in conjunction with said conduit comprising a stationary axis for the mounting of said rotor therearound.

16. In an evacuating silencer as described in claim 1, bearing assemblies in said smaller diametered end comprised of a multiplicity of individual, taperingly edged wheels mounted tandemwise on axles positioned in individual brackets, said brackets being removably secured to said solid annular wall, each of said wheels having anti-frictional bearing assemblies inserted in their hubs for permitting free rotation thereof around said axles during the rotation of said trackways thereagainst.

17. In an evacuating silencer as described in claim 1, the outer wall of said rotor being comprised of a twin-half construction, means for removably securing each half to the other, said walls being stress-supported by bands secured at right angles thereto and extending circumferentially therearound.

18. In an evacuating silencer as described in claim 1, said casing having a framework comprised of walls of twin-half construction, said walls being stress-supported by right-angular bands secured thereto and extending circumferentially therearound, open-mesh means secured to the inner surface of said casing walls for safeguarding the rotor mounted therewithin.

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