

Oct. 17, 1939.

H. P. SPARKES

2,176,773

ARTICLE OF MANUFACTURE AND METHOD OF PRODUCING SAME

Filed April 26, 1937

2 Sheets-Sheet 1

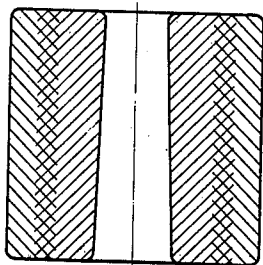


Fig. 1.

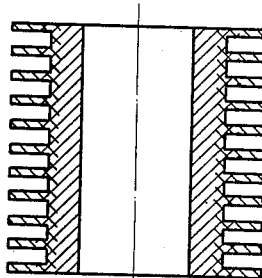


Fig. 2.

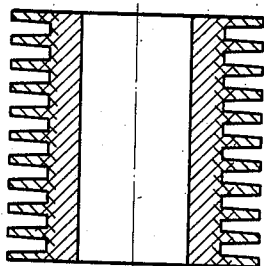


Fig. 3.

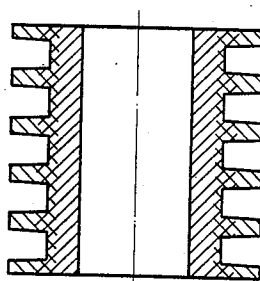


Fig. 4.

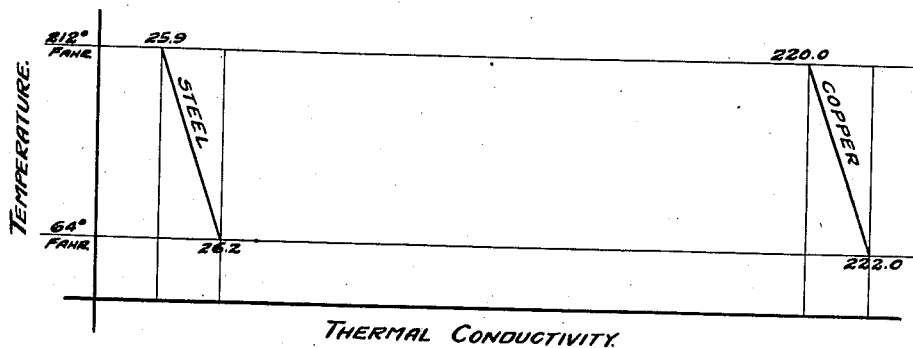


Fig. 5.

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2 Sheets-Sheet 2

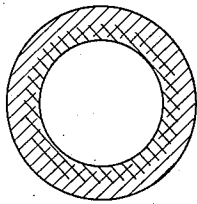


Fig. 7.

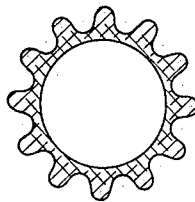


Fig. 9.

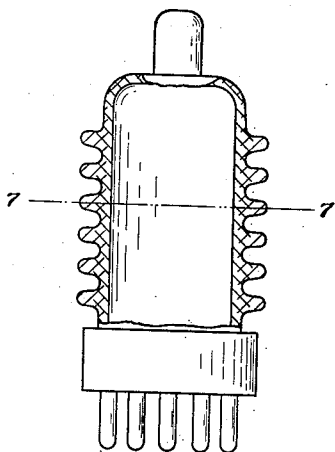


Fig. 6.

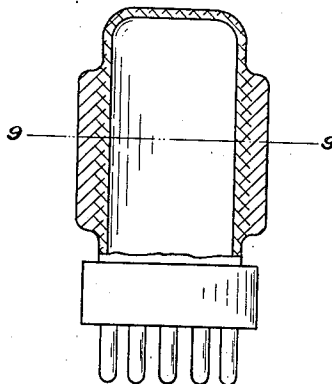


Fig. 8.

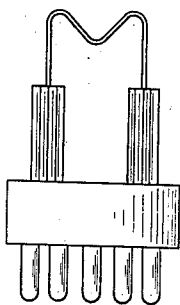


Fig. 10.

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ARTICLE OF MANUFACTURE AND METHOD OF PRODUCING SAME

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Application April 26, 1937, Serial No. 138,873

7 Claims. (Cl. 29—156.4)

This invention relates to the construction and method of producing heat-dissipating cylinders, which has as its principal object a composite construction wherein the radiating surfaces are made from a material of high heat conductivity, and the mechanical walls of the cylinder are constructed of a wear-resisting material. It is recognized that considerable weight of an air-cooled internal combustion engine cylinder is made up of the cooling fins. If these cooling fins used on various forms of aircooled engines could be built rugged and yet have a higher thermal efficiency, the weight of the present ferrous cylinders might be considerably reduced. This is vitally important in aeronautics, as it would eliminate many pounds of dead weight from the engine of the ship. Likewise, it would be valuable in the reduction of weight in stationary air-cooled engines, or for motor vehicles, or compressors.

It is recognized that the dissipation of copper is many times greater than steel, and it is the purpose of this invention to construct a perfectly solid cylinder fused from a cuprous material to act as radiating fins, and a ferrous material to act as the mechanical cylinder wall. Many attempts have been made to accomplish this same result, and have consisted of either the mechanical joining of a copper jacket over a ferrous cylinder, the welding of copper fins to the cylinder, or by the casting of the cylinder and fins together with certain mechanical joints. None of these have provided a satisfactory cylinder, for in producing a cylinder with these qualities, it is necessary to have a perfect thermal connection between the inner walls of the cylinder and the radiating fins or external walls of the cylinder which will dissipate the heat. The welding process, although providing a perfect thermal connection, is unsatisfactory in that the welding produces warping and unbalanced strains in the cylinder, which results in mechanical failures.

Furthermore, none of these structures have provided a continuous fused joining of the two metals together. I have, in the case of a cylinder, joined the two metals continuously together by the actual melting of the one into the other to a limited depth; and in the case of a cylinder head, I have joined the two metals together continuously for a limited depth throughout the surface area thus effected. This is not only done for the benefit of increased thermal efficiency of the radiating surface, but also for its compensating effect as later described in this application,

which produces a stable machine element at operating temperatures. In those structures in which a radiating fin is welded or brazed to the cylinder wall, there is only a limited joint, and the compensating effect produced by the continuous joining as herein described is not obtained; in fact, exactly the reverse is accomplished. This is the reason why attempts to obtain this result to date have been failures. Ribs of a material of relatively high coefficient of expansion fused intermittently to a cylinder wall, while increasing the radiation, obviously serve to set up strains which either break the joint or distort the cylinder wall.

In describing my joint as "continuous", it is to be understood that a continuous fusion of one element to the other is contemplated, and over an area sufficient to produce a compensating action. "Continuous" does not necessarily mean the enveloping of one cylinder with another, but could mean, and is to be construed as meaning in the application, the adjoining of two walls by fusion, to such an extent as is required to effect thermal compensation without distortion of either member.

It is the purpose of this invention to provide what might be termed a heterogeneous cylinder, in which it is preferred to use a cuprous material for the radiating fins, and a ferrous material for the mechanical cylinder. The thermal conductivity of copper is relatively high, and the wearing qualities of the ferrous material is required to withstand the continuous rubbing action of the piston. It is therefore preferred to use these materials, but it is understood that any other combination which would produce the same effect is contemplated in this invention.

Although the cylinder is especially designed for use in internal combustion engines, and in particular as applied to aircraft, the same principle obviously can be used for any problem wherein there is desired a mechanical wearing quality on the one side, and a heat-dissipating quality on the other. The principle of joining two metals to form a heterogeneous ingot is known and used in the manufacture of "copperweld" wire.

The practice is to provide a steel ingot or casting which is of correct shape and size for making a cylinder, and then after pickling this casting, it is brought up to a temperature in excess of the melting point of copper and placed in a mold, whereupon molten copper is poured around it to form the heat-dissipating jacket. This copper may be cast into shape during this

operation, or may be made in a solid form suitable for machining.

Another method is to provide a copper shell which may or may not be prefinished to its ultimate form, and to pour into the copper shell molten ferrous metal, the temperature and heat of which will be sufficient to melt into the copper, and to cause a fusion resulting in a heterogeneous mixture of the ferrous and cuprous materials, the one lapping into the other for a considerable distance. This results in a cylinder in which the external part is a metal which has a high heat conductivity, and an internal bore which has a lesser heat conductivity, but a higher mechanical wearing quality. The cylinder produced by this method has an advantage in that the coefficient of expansion of the inner or ferrous material is less than the coefficient of expansion of the outer or cuprous material, and this permits the cylinder to expand rather uniformly and without excess strain being developed in its larger dimensions.

I have found in experimenting with a cylinder made according to the practice outlined in the application, that for internal combustion engines, this compensating feature of one metal fused to the other is very important. In the ordinary cylinder now used for automobiles and aircraft, there is a tendency of the cylinder to grow in size, due principally to heating and cooling. When a cylinder is heated, especially as in internal combustion engines, it is intensely heated from the interior, and there is an excessive expansion of the metal on the interior of the cylinder, and a lesser expansion of the material at the exterior. This interior expansion is so powerful as to actually stretch the outer portion of the cylinder wall. When the cylinder cools, the exterior then being "stretched", is unable to fall back in its entirety to its original position, resulting in stretching the inner portion of the cylinder wall, and this repeated many times, tends to make the cylinder larger, and is known as "growing." In my device, the external metal has the higher coefficient of expansion, which permits it to expand more rapidly for a given rise in temperature, which in normal practice is a lower temperature than that inside of the combustion chamber. At the same time in my device, the inner wall of the cylinder has a lower coefficient of expansion and therefore expands less per degree of temperature rise, thereby compensating for the greater heat at the interior of the cylinder. The heat permeating the cylinder wall reaches the outer jacket where the thermal conductivity and radiation is greater than the inner wall, and this therefore causes the outer wall to operate at a lower temperature than the inner wall. This compensated action caused by the reversal of the coefficient of expansion and conductivity with respect to the amount of heat applied, automatically permits the cylinder to remain in a normal state without strain, and consequently not subject to the usual "growing" and resultant strains. This action applies equally to the diameter of the cylinder as well as to the length of the cylinder, and it also applies to the cylinder head which likewise might be compensated for the same reasons.

This action obviously is very important in air-cooled engines. It is well known that present aircraft engines have to have their cylinders bored conical with a taper so that the explosion end of the cylinder is several thousandths smaller in diameter than the crank end of the cylinder.

This corrects for unbalanced temperature in the head of the cylinder, and for the "growing" action produced by this unbalanced temperature. After a certain number of hours of use, the cylinders have to be replaced because excessive developments in temperature have caused "growing" to where the piston fit is improper, and the compression clearances have changed sufficiently to interfere with the efficiency of the engine.

In present aircraft practice, the large difference in temperature between the inside of the cylinder head and the outside of the cylinder head causes the cylinder head to "grow." This action fatigues the metal in the head, causing the head to rupture under normal pressures. Many reports show aircraft cylinder head failures, especially in the aluminum type of head. It is believed that these ruptures are due to metal fatigue caused by the constant stretching or "growing" action set up by the heat differential from the inner surface to the outer surface of the head. I have found that a temperature-compensated head overcomes this difficulty.

The use of this compensation would eliminate the necessity of ageing the cylinder casting, as well as the head casting, before they are used, as is now the practice. The usual strains now set up in the molding of an automobile engine block, for instance, would be largely eliminated.

The fact that the flow of heat is from the gas generated in the cylinder into the ferrous walls and thence into the copper radiating fins, means that the expansion would be gradual and the part of the cylinder which is required to expand the most is free to do so and at the same time has the greatest thermal conductivity. A cylinder produced by this process has a perfect thermal flow and at the same time the two materials are so overlapped or fused that there are no joints to come loose or to set up strains in the cylinder. I have found that a cylinder made in accordance with my construction and process has a great mechanical strength, and makes it possible to reduce the weight of the cylinder considerably, and furthermore, the greater coefficient of the radiating fins on the cylinder permits of the use of smaller fins of less weight for the same radiation now obtained from a steel cylinder with steel fins.

There are many methods by which my cylinder may be produced, and these are all contemplated as a part of my invention. A heterogeneous ingot with a cuprous external material and a ferrous internal material may be formed by mounting a copper shell in a foundry mold and then pouring molten steel into the center, whereupon the steel fuses the copper, and the two are completely fused together. From this ingot the cylinder may be machined by boring away the center of the steel core and leaving enough steel to form the piston wall, then the copper jacket is machined into the form of radiating fins.

Another method of producing the cylinder is whereby the ingot is formed as before, and then the copper fins are forged or pressed from the copper jacket. The bore for the piston would be machined from the center of the steel core. Obviously, the steel core could be cast hollow, so as to require the removal of less metal.

Another method might contemplate the actual forming of the fins on the copper by a casting process before the steel is cast.

Another way to produce the cylinder is to use a steel ingot with my copper jacket fused thereto, which is heated red and squeezed in a forging

machine to form the cylinder shell. This is common practice in the manufacture of aircraft cylinders at the present time, and is particularly adaptable to my plan.

In order that the details of construction may be better understood, reference is made to the accompanying drawings, in which:

Figure 1 is a vertical section showing an ingot, and the extent to which the steel cylinder wall fuses with the copper jacket.

Figure 2 is a section showing a cylinder machined from the heterogeneous ingot shown in Figure 1.

Figure 3 is a section showing a cylinder as in Figure 1, but with the fins forged in the copper and the cylinder bored out to receive the piston.

Figure 4 is a section showing a cylinder as described in the third process, wherein the fins have been precast with the copper jacket, whereupon the steel has been poured and fused into this element.

Figure 5 is a diagram showing the thermal conductivity of steel as against copper, and explains the relative elimination of weight as a result of the higher thermal conductivity of the material used in the fins of the cylinder.

In describing this invention, the cylinder of an internal combustion engine seems to be the most common example and one of the largest fields of application of the principle involved, but it is not intended to limit the invention to this particular field, and for this reason a second sheet of drawings showing the application of the principle to radio transmitting tubes has been included.

In this application, Figure 6 shows an elevation partly in section of a radio transmitting tube in which the radiating fins are made of a material of high conductivity and the shell itself of a material of lesser conductivity but greater mechanical strength.

Figure 7 shows a section taken on the line 7-7 in Figure 6.

Figure 8 is an elevation partly in section of a radio transmitting tube in which the fins have been run in an axial direction.

Figure 9 is a section taken on the line 9-9 in Figure 8.

Figure 10 shows the application of the principle to the uprights which support the elements within the tube.

In radio transmitting tubes, the heat to be dissipated is intense and many of the parts are constantly burned away. By use of the principle described in the invention, a satisfactory dissipation of the heat occurs and at same time the required mechanical strength for the parts is retained.

Likewise, this same principle may be applied to other parts where mechanical strength is required and insufficient conductivity is secured through the use of the usual materials, such as the head of an internal combustion engine. It is likewise applicable to certain heating devices, such as radiators, furnaces, or boiler parts.

It should be pointed out that in making any of these articles, it is necessary to have the copper shell of sufficient weight to withstand the heat delivered by the iron or steel being cast against it, so as to cause only a partial fusion of the iron into the copper. Obviously, if the copper shell is too thin to withstand a partial fusion and has not sufficient body to absorb and carry away the additional heat, it would be entirely melted, and perhaps burned away. The copper shell

during the casting operation acts as an absorber of a sufficient amount of the heat carried in the molten steel, and this is very necessary, otherwise the steel will entirely burn away the copper and probably absorb all of the copper into itself.

It is a purpose of this invention to include all of these possible applications wherein the process of producing a heterogeneous element with high strength on one side and increased conductivity on the other side is used.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The method of producing a mechanical cylinder, consisting of the use of an exterior jacket with a continuous internal surface, and made from a metal of high thermal conductivity, into which is poured a lining of metal of high wear-resistance and relatively low thermal conductivity, the said metal having a higher melting point than the external jacket wall, and thereby causing a fusion of the internal metal into the external metal to a limited depth, and the machining of a bore through the cylinder, and the machining of radiating fins into the external jacket.

2. The method of producing a mechanical cylinder consisting of the use of a rigid exterior jacket with a continuous internal surface made from a metal of high thermal conductivity, into which is poured an annular lining of metal of high wear-resistance and relatively low thermal conductivity, the said metal having a higher melting point than the external jacket wall, and thereby causing a fusion of the internal metal into the external metal to a limited depth, and the machining of a bore through the cylinder.

3. The method of producing a mechanical cylinder consisting of the use of a rigid exteriorly finned jacket with a continuous internal surface and made from a metal of high thermal conductivity into which is poured an annular lining of metal of high wear-resistance and relatively low thermal conductivity, the said metal having a higher melting point than the external jacket wall, thereby causing a fusion of the internal wall metal into the external metal to a limited depth, and the machining of a bore through the cylinder.

4. The method of producing a mechanical cylinder consisting of the use of a rigid exterior jacket with a continuous internal surface and made from a metal of high thermal conductivity, into which is poured a lining of metal of high wear-resistance and relatively low thermal conductivity, the said metal having a higher melting point than the external jacket wall and thereby causing a fusion of the internal metal into the external metal to a limited depth, and the machining of a bore through the cylinder and the machining of radiating fins into the external jacket.

5. The method of producing a cylinder consisting of the casting of a rigid external jacket with a continuous inner wall from a metal of high heat conductivity and relatively low melting point, the placing of the said jacket in a mold, the pouring of an annular cylinder wall of a metal of relatively low thermal conductivity and high melting point into the said jacket, thereby fusing the one metal into the other for a limited depth, and the machining of a bore in the cylinder.

6. A bored cylinder comprising a rigid external jacket with a continuous internal surface made from a metal of high thermal conductivity, into which has been poured an annular lining of

metal of high wear resistance and relatively low thermal conductivity, the said metal having a higher melting point than the external jacket wall, which when poured, causes a fusion of the internal metal into the external metal to a limited depth.

7. A bored cylinder comprising a rigid external jacket with a continuous internal surface made from a metal of high thermal conductivity and

high co-efficient of expansion into which has been poured an annular lining of metal of high wear resistance and relatively low thermal conductivity and low co-efficient of expansion, the said metal having a higher melting point than the external jacket wall, which, when poured, causes a fusion of the internal metal into the external metal to a limited depth.

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