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(56) Documents cited

GB A 2063429	GB 1162845	GB 0988596
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GB 1275550	GB 1101613	EP A2 0010509
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(58) Field of search
F3A
Selected US specifications from IPC sub-class F42B

(54) Shotgun cartridges

(57) A shot gun cartridge exhibiting a peak pressure within the normal range (400 to 700 bars) characterised by an end closure which opens under a negligible to weak force such that the peak pressure developed in the absence of the closure is lower by 20% or less than that developed with the closure in place. The closure is formed from teeth folded inwards in a dome shape and secured at the centre or is formed by a frangible or displaceable disc.

FIG.8b.

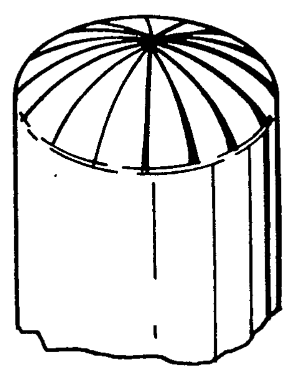

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FIG.1.

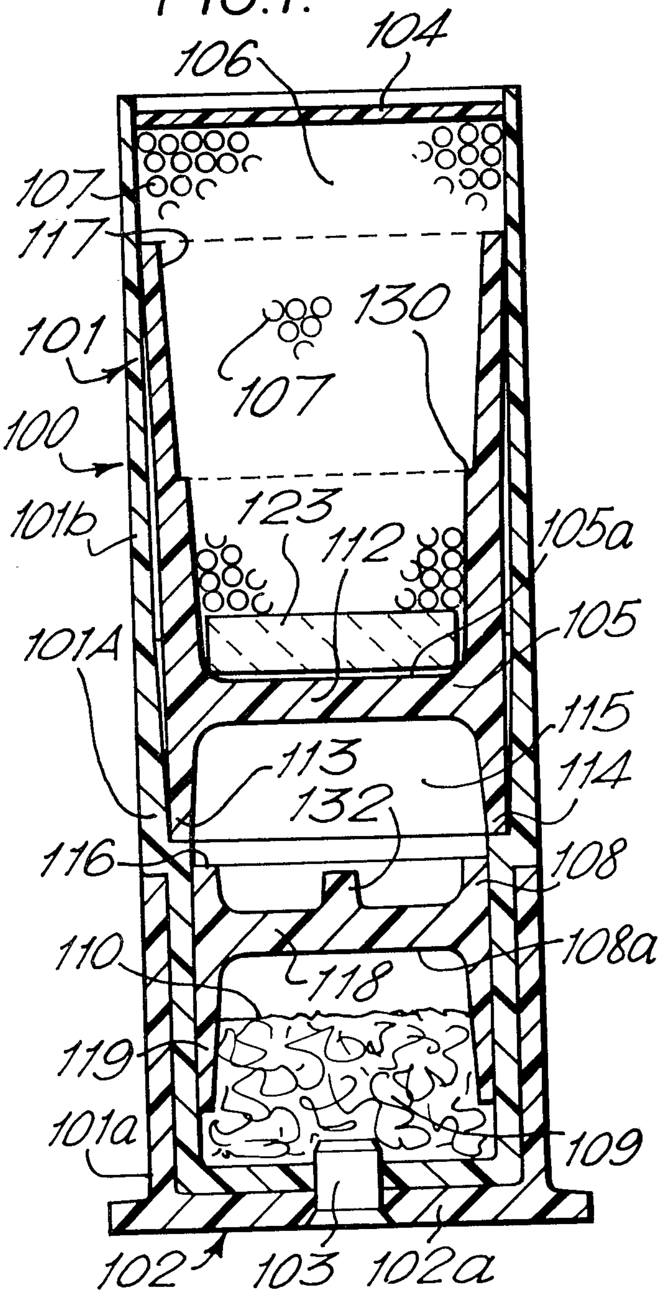
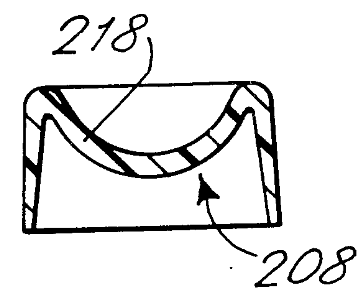


FIG.2a.



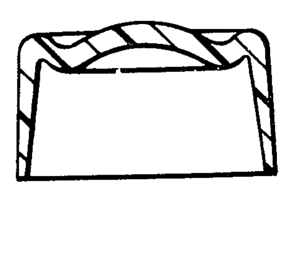


FIG.2b.

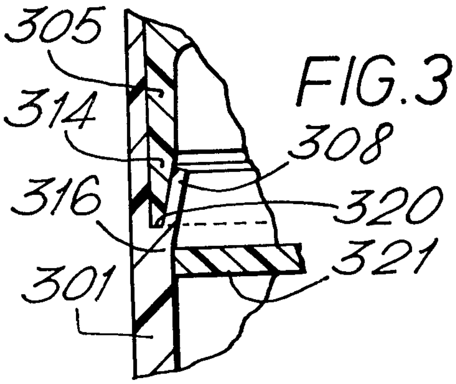


FIG.3a.

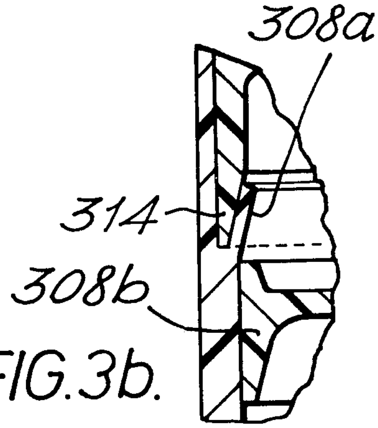
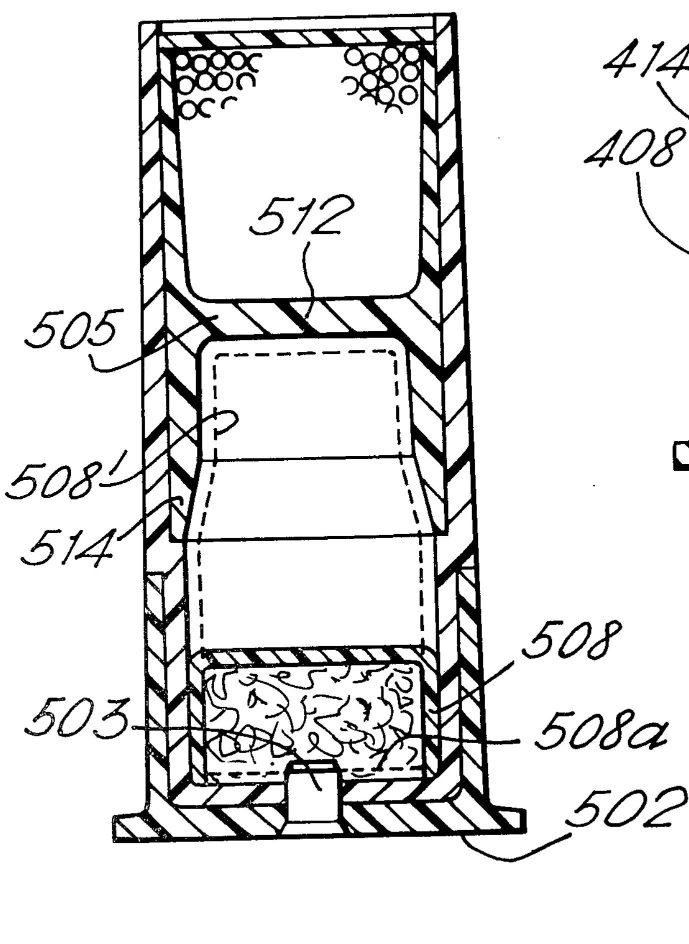


FIG.3b.

FIG.5.



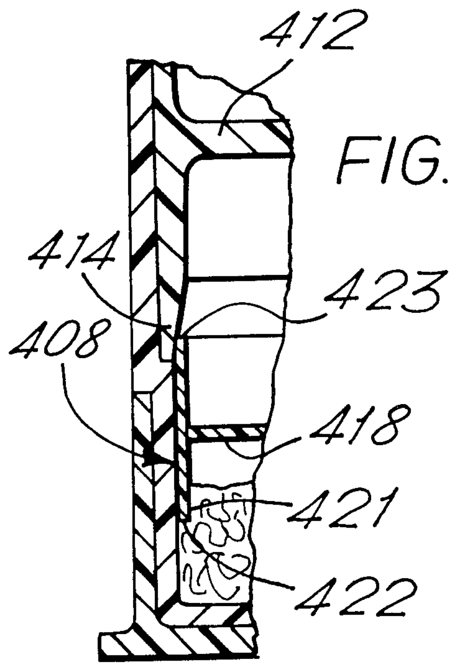


FIG.4.

FIG.6a.

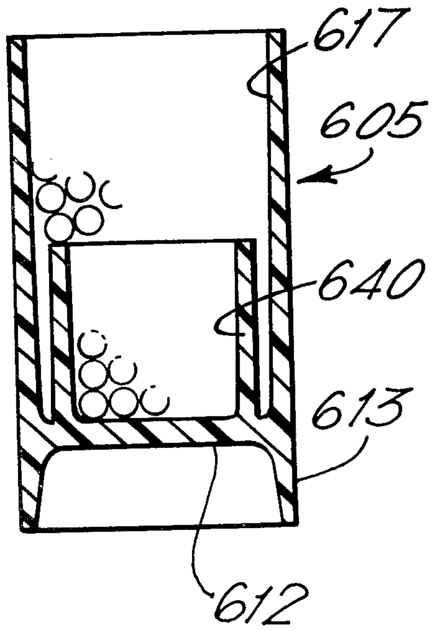


FIG.6b.

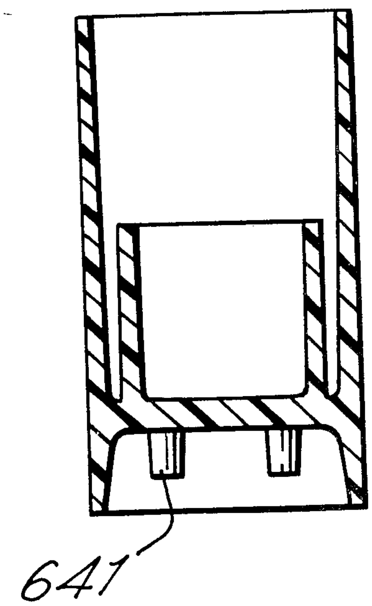


FIG.6c.

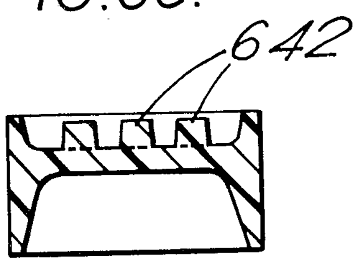


FIG.6d.

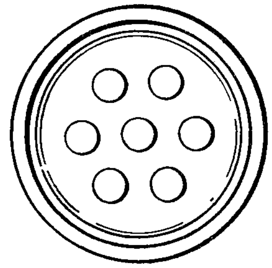


FIG.6e.

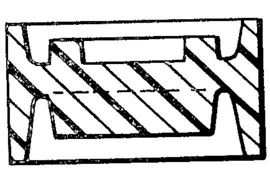


FIG.6f.

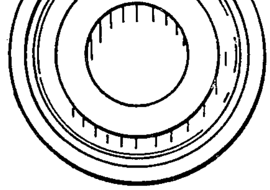


FIG. 7a.

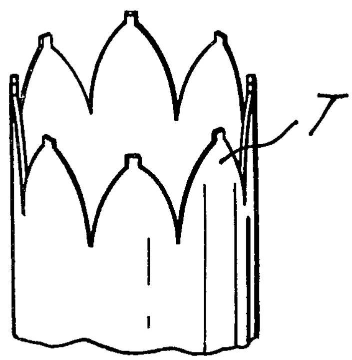


FIG. 7b.

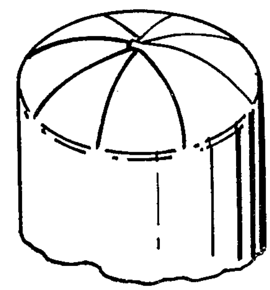


FIG. 8a.

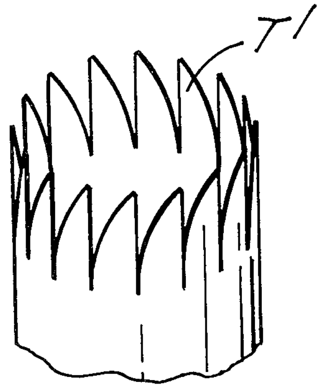


FIG. 8b.

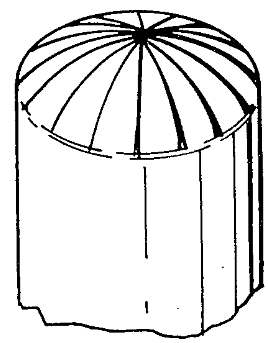


FIG 9.

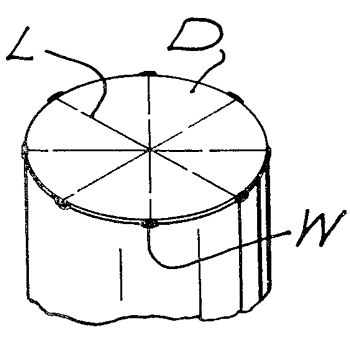


FIG. 10.

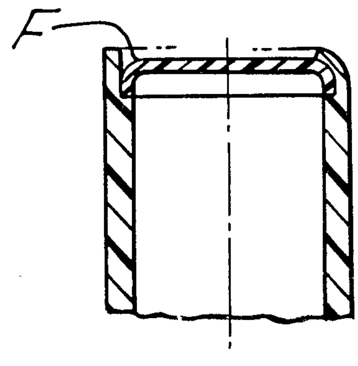


FIG. 11.

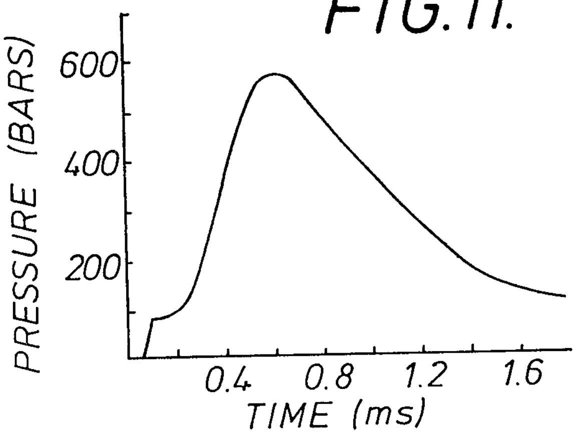


FIG. 12.

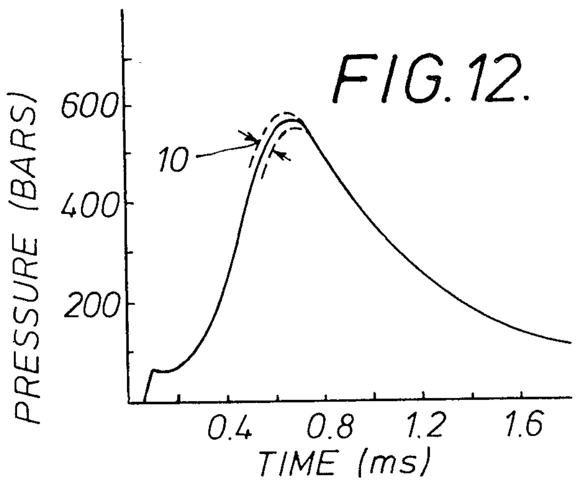


FIG. 13.

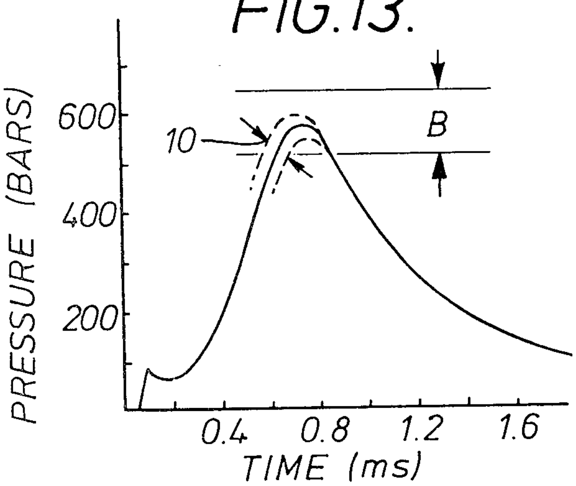


FIG. 14.

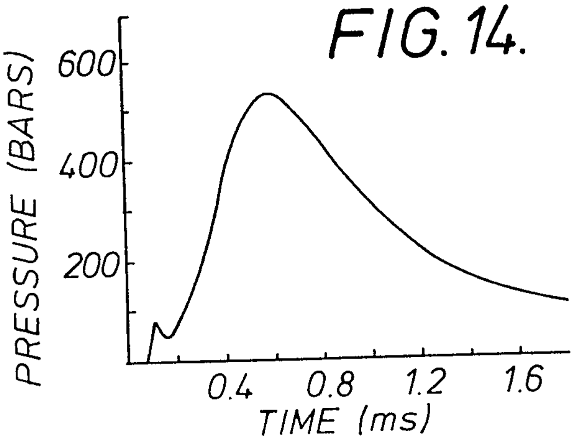


FIG. 15.

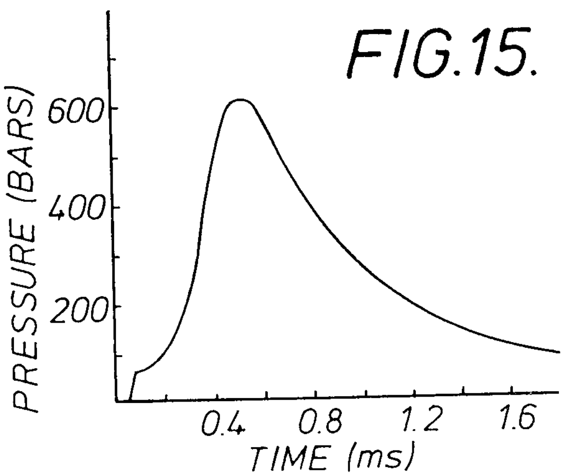


FIG. 16.

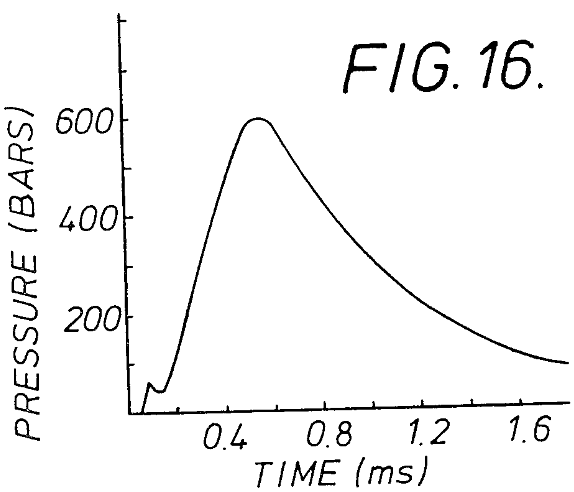


FIG.17.

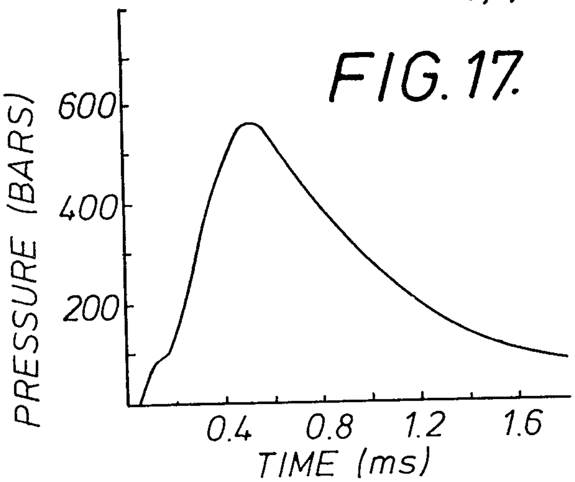


FIG. 18.

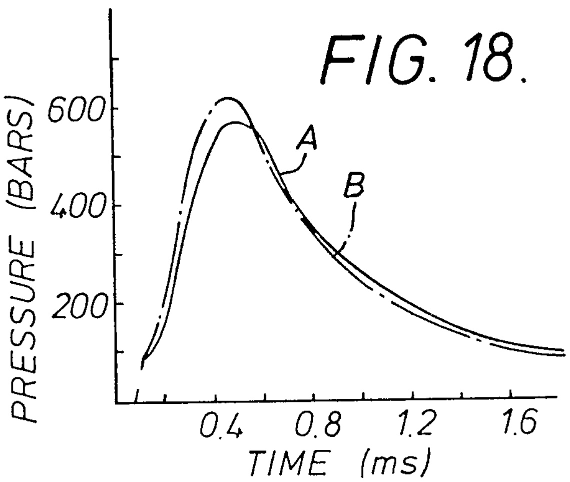
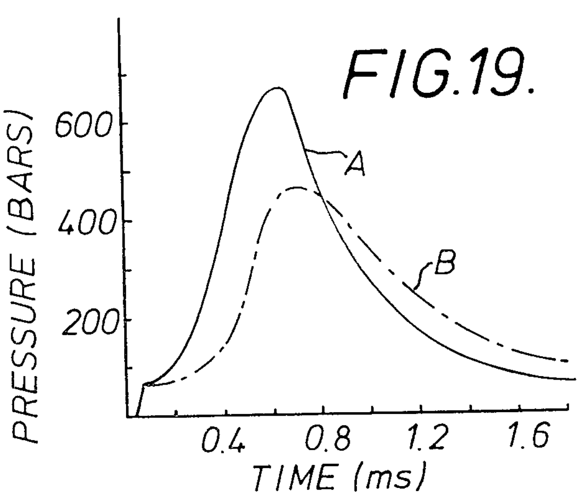


FIG.19.



SPECIFICATION

Shotgun cartridge with low resistance closure

The present invention relates to shotgun cartridges and is more particularly concerned with cartridges of improved efficiency and regularity and economy of manufacturing. The present application is one of three concurrent applications which collectively relate to cartridges of fundamentally new design. The remaining applications are identified by application Nos. 8507978 and 8507980.

Conventional shotgun cartridges comprise a case having a cylindrical wall and a base holding a percussion ignition means, the cartridge including an end closure and obturating means having an upper face defining with the end closure a shot chamber containing shot and having a lower face defining with the base a space containing propellant in communication with the ignition means.

The obturating means conventionally used is a wad normally of moulded polyethylene which has a collapsible structure. The wad is forced down against the propellant and after positioning of the shot the end of the cartridge is crimped, forcing the wad under pressure against the propellant. The dynamic pressure applied by the crimp and the partial collapse of the wad under the crimp force are determining factors in the rate of combustion of the propellant and in turn the peak pressure generated in the gun barrel which for safety reasons should not normally exceed about 600 bars.

During combustion the combustion pressure rises to a maximum and then falls away as the accelerating velocity of the wad and shot becomes faster than gas generation, giving rise to a characteristic pressure/time curve.

In producing commercial shotgun cartridges, the main effort in recent years has been directed towards the production of reliable, i.e. closely reproducible cartridges. In the case of conventional cartridges this requires very careful control and skill in the production operation since the number of variables affecting regularity is considerable. Partly as a result, comparatively expensive cartridge case materials have been used e.g. bi-axially oriented plastics with the tensile and impact strength mainly to cope with the crimp-opening resistance and which are waterproof and dimensionally stable. The propellant cost being relatively small, comparatively little effort has been made to improve efficiency of operation. Furthermore, since so much know-how and customer acceptance has accumulated in the use of the crimp, there has been reluctance to investigate other types of cartridge design.

The present inventor has approached the question of cartridge design from first principles. As a result a fundamentally new cartridge has been designed as will become apparent from the embodiments to be described. The embodiments exhibit an inventive approach in three different design parameters which are interdependent viz:- the obturator, the end closure and the case. When these inventions are combined, substantial benefits are achieved. However each invention gives rise to advantages when used independently.

The wads of conventional cartridges have the purposes of compressing the propellant to control combustion rate, of sealing the gases during firing and of driving the shot. They act as separators between the propellant and the shot and are usually constructed so as to collapse soon after ignition e.g. at a pressure of less than 100 bars. The process of collapse serves to control the rate of combustion and thus the peak pressure. Once the wad is fully compressed against the shot it is supported and even relatively poor sealing wads provide an effective seal.

The first problem is in determining a reproducible combustion rate by the manipulation of too many variables i.e., the degree of pressure applied to the propellant, the compressibility of the wad, the crimp opening force, the quality of the initial wad seal, the tensile strength of the case and the speed and quantity of propellant and primer strength. Regularity under these conditions becomes an art and requires skilled operators and expense of manufacture. Even with expensive cartridges regularity may be poor, and all calibres and shot weights have different effects on regularity.

I have found that one of the regularity problems lies in the adequacy of the seal in the early stages of combustion especially at the instant of ignition and immediately afterwards. At this stage leakage occurs which not only lowers efficiency but gives rise to irregularity of ignition and variations in the rate of combustion. The following factors may contribute to the leakage:

1. The cartridge case has to be a loose fit within the gun to allow for gun and case dimensional variations (0.12 to 0.5 mm).

2. The wad must be a sliding fit within the case to allow the wad to be forced down on to the propellant with a reproducible force. In practice the propellant is precompressed by a given force in the range of 7 to 18 kg. This is done to reduce the air space and increase the ignition pressure.

3. Even if an interference fit could be used, depending upon the type of material of the cartridge case, this would often cause swelling and oversize cases.

4. Normally at ignition, the pressure rises to around 100 bars in a few microseconds, whereas the time taken for the pressure to compress the seal and case to the gun is of the order of 100-200 microseconds. In this period gas leads past the wad reducing ignition pressure and efficiency.

A third problem is concerned with cartridge case material. Due to the severe strain imposed by the opening of the crimp, considerable tensile strengh has to be given to the cartridge wall. Modern cartridges normally employ bi-axially oriented HD polyethylene as the case material, which does not permit of injection moulding so that the expense is high. It is known to injection mould cartridge cases of high density polyethylene but this process requires very high tonnage machines and gives only reduced orientation, i.e. lower strength. Furthermore, the injection moulder has to work under abnormal conditions near to solidity for the final phase of moulding.

The Collective Concept

The collective concept exhibited in the principal embodiments and to which this invention contributes involves a redesigned cartridge incorporating the following principal design changes:

1. the end closure is weak or insignificant;
2. the obturator means is divided and the upper component is in a predetermined location defining a combustion chamber of known volume;
3. a sealing member, preferably formed as a sliding second wad member, confines the propellant before and at ignition and permits good ignitability of the propellant and repeatable initial expansion;
4. the propellant is essentially under no initial pressure;
5. the cartridge case is of injection moulded, low tensile strength material, preferably with a thicker walled base section;
6. the cartridge case is made of two different materials to give the properties required in the case wall and at the head and rim. This is achieved by moulding the parts so that they are molecular bonded, i.e. have become one component;
7. normal propellant of reduced quantity is used to achieve equivalent performance;
8. ballistic design for changes in calibre, shot weight and velocity etc. can be easily accommodated by changing the design of the lower seal including its weight and position.

It is immediately apparent that the expense of the cartridge is reduced overall. Since the end closure is weak, little or no strain is imposed upon the cartridge case during opening of the closure and this permits materials of relatively weak tensile strength to be used in the cartridge case. Such materials can be injection moulded and the cases are relatively cheap to produce. The cartridge mode of operation is redesigned to eliminate pre-compression of the propellant, to fix the main wad and shot position, and to reduce drastically the effect of the closure on ballistics. Removal of the strong closure or crimp using existing primers and propellants is permitted by improvement in combustion efficiency and regularity. This is achieved by improvements in sealing, particularly at ignition, by the use of mass around the propellant, by dimensional accuracy and improvements in design under which components operate in fixed positions. The resulting improvement in regularity allows the use of higher average pressures. This, together with the better sealing, reduces propellant requirement giving greater efficiency. The reduction in leakage reduces recoil for a given velocity and improves pattern. The reproducible ignition and combustion allows simple redesign for calibre and weight changes, using fewer grades of propellant. Control of ballistics is easily achieved by change in the second wad member weight or stiffness. A change from 0.7g to 1.0g has a greater effect than existing crimps.

While it is apparent from the above that the collective concept, or cartridge embodiment involves a number of redesigned interacting parameters, at least certain of them can be used independently or in combination with others without necessarily requiring all of the remaining parameters to be present.

For example, the advantages of a weak closure together with an injection moulded low tensile strength cartridge case can to some extent be achieved by an appropriate redesign of the obturator means and if necessary the propellant system without utilising other of the inventive parameters.

Furthermore the advantages of a two-component injection moulded cartridge case could to some extent be achieved utilising a cartridge with a conventional but moderate crimp, with improved sealing in the obturator and/or a propellant of improved ignitability.

For the above reasons the present invention is concerned with end closure design, that of application No. 8507978 is concerned with obturator design and that of application No. 8507980 is concerned with cartridge case design.

In accordance with the present invention there is provided a shot gun cartridge exhibiting a peak pressure within the normal range (400 to 700 bars) characterised by an end closure which opens under a negligible to weak force such that the peak pressure developed in the absence of the closure is lower by 20% or less than that developed with the closure in place.

Preferably the said peak pressure is lower by 10% or less.

The closure may be formed of material integral with the cartridge case or may include a separate closure member. This may for example be a frangible disc, spot welded or bonded to the end of the open cartridge or a closure which is removed by the exit of the shot. In the latter case the closure may be in the form of a disc held in place by deformation of material of the case or by spot welding or spot bonding to the open end of the case.

In one embodiment the end closure is formed from teeth moulded or cut in the case mouth and folded inwards in a dome shape so that adjacent teeth meet along generally coincident lines, and spot welding or spot bonding the teeth together at the centre.

In another embodiment the end closure is formed from teeth moulded or cut in the case mouth and folded inwards in a dome so that adjacent teeth overlap and are spot welded or spot bonded at the centre.

The tabs may be shaped so that the visible edges are either radial or of a spiral formation.

The cartridge of the present invention preferably includes features of the inventive parameters separately claimed in the aforementioned concurrent applications.

Thus the preferred cartridge comprises a case having a cylindrical wall and a base holding a percussion ignition means, the cartridge including an end closure and an obturating means having an upper face defining with the end closure a shot chamber containing shot, and having a lower face defining with the base a space containing propellant in communication with the ignition means,

characterised in that the end closure is of fixed position and defines a fixed volume and the obturating means includes a first wad member having an upper face bounding the shot chamber and which is located at a fixed position within the cartridge case so that its lower face determines a combustion chamber of predetermined volume, the position of the shot being fixed between the upper face of the obturating means (including any spacer member) and the end closure.

Preferably the cartridge includes a first wad member which is located so as to determine the upper wall of a combustion chamber of greater volume than that occupied by the propellant and a sealing member which is arranged to confine the propellant within a propellant chamber at the lower end of the combustion chamber prior to ignition.

Preferably the first wad member comprises a web having a first flange portion extending towards the sealing member and terminating in a lip portion, the web and flange portion defining a seal cavity and the sealing member is arranged to engage the lip portion upon ignition.

Preferably the base of the cartridge is formed with an extraction rim and means for receiving a cap and wherein a base outer section, including the extraction rim and an adjacent wall outer surface portion, is formed separately from the remainder of the case and joined thereto under heat and pressure. The base outer section and the said remainder are preferably formed by injection moulding.

The base section is preferably of greater tensile and/or impact strength than the said remainder which may be less than 4000 psi (2800 N/cm^2), e.g. biologically degradeable material.

Preferably a base wall portion coextensive with the base outer section is of greater thickness than the remaining end portion of the cartridge (the outer surface of the case being uninterrupted) and a step is formed in the inner surface of the case. The base wall portion may have an impact strength of 15-30 Joules/cm^2.

The preferred cartridge includes a first wad member located against the said step so that its lower face determines a combustion chamber of predetermined volume.

Preferably the cartridge includes a second wad member positioned as an interference fit against the thick wall portion of the case wall.

Preferably the second wad member is located so as not to place the propellant under significant pressure.

The second wad member may engage within a sealing cavity within the first wad member, or first and second wad members may be dimensioned so that the second wad member slides upon ignition to fit within a sealing cavity in the first wad member.

One form of first wad member contains no compressible wad or other filler member in the shot cup and is formed with an inner sleeve portion extending upwardly from the web for part of the length of the wad, the inner sleeve being spaced from the inner wall of the wad member by a distance less than half the diameter of a shot pellet.

Embodiments of the invention are hereinafter described with reference to the accompanying drawings in which:

Figure 1 is a longitudinal section through a first form of cartridge in accordance with the invention

Figure 2(a) and (b) show the shape of another possible form of sealing member at different stages,

Figure 3a is a longitudinal section through part of one wall of the cartridge in a section similar to that of Figure 1, showing a second embodiment,

Figure 3b is view similar to Figure 3a showing a form in which the embodiments of Figures 1 and 3a are combined.

Figure 4 is a view similar to Figure 3 of a third embodiment,

Figure 5 is a view similar to Figure 1 of a fourth embodiment,

Figure 6a-f show first wad member and sealing member designs to give integral cushioning and avoid cork inserts,

Figure 7a and b show an integral weak star closure in the open and closed positions respectively,

Figure 8a and b show an integral weak iris closure in the open and closed position respectively,

Figure 9 shows a welded groove-weakened disc closure,

Figure 10 shows a disc closure using a weak roll turnover.

Figures 11 to 19 are pressure/time graphs showing the operation of different embodiments of the invention compared to conventional cartridges.

In the drawings equivalent parts where possible are given the same numeral preceded by different initial digits according to the figure.

The cartridge of Figure 1 comprises a case 100 having a cylindrical wall 101 and a base 102 holding a percussion ignition means 103, an end closure 104, a first wad member 105 the upper face 105a of which supports a compressible wad e.g. of cork 123 which is a loose fit. The upper face of the spacer 123 defines with the end closure 104 a shot chamber 106 of fixed volume containing shot indicated at 107. The first wad member 105 in this embodiment is separated from a sealing member in the form of a second wad member 108, the lower face 108a of which defines with the base 102 an ignition chamber 109 containing propellant 110.

The cartridge case 100 is, in accordance with a preferred feature of the invention, formed in two joined parts. A base outer section 102a which includes an extraction rim 111 and an adjacent wall outer surface portion 101a is formed separately from the remainder 101b of the case and joined thereto under heat and pressure. In this way the base outer section 102a can be made of greater tensile and/or impact strength than the remainder 101b. Thus the base section 102a may be made for example of linear medium or high density polyethylene and the remainder 101b of linear medium or low density polyethylene. Each section can be made by injection moulding. Preferably the parts are moulded together in a single moulding cycle, the part 101b being molded against the part 102a.

The construction in two components is of particular advantage in that cheap materials and processes can be used where possible. It allows the base outer section 102a to be made of a different colour from the remainder 101b, e.g. of a colour resembling metal. Furthermore, the remaining part 101b can be made of a weaker biologically degradable material e.g. by including starch in an amount up to 40% by weight. It may have a tensile strength of less than 4000 psi (2800 N/cm^2).

A further advantage lies in the stepped configuration of the case. The base portion formed of laminated layers 102a and the contiguous part of the remainder 101b is of greater thickness than the remaining end portion of the cartridge, a step being formed in the inner surface of the case. This provides a convenient abutment for the upper wad member and allows a lower wad member to be of smaller diameter and to be interference fitted. The base portion preferably has an impact strength of 15 to 30 $joules/cm^2$.

The construction of the cartridge wall of essentially weak materials is aided or made possible through the use of the positively located first wad member normally in conjunction with the sealing member as will become apparent and also the use of a weak end closure. In the embodiments of Figures 1 to 6 the end closure is shown formed of a simple disc closure (104) which is held in place frictionally and this system with low resistance was used for experimental purposes. In practical commercial embodiments of Figures 1—6 and in all later experiments the closures described in Figure 7 and 8 are used.

The first wad member 105 comprises a web 112 having a first flange portion 113 extending towards the second wad member 108 and terminating in a lip portion 114, the web and flange portion defining a seal cavity 115. As shown, the interior surface of the lip portion 114 tapers towards the web. The lip portion 114 fits with a light interference fit in the case which narrows at this part.

The first wad member 105 is positively located at a predetermined position within the cartridge, separated from the propellant. The positive location may be made by resting the lip portion 114 against an abutment on the cartridge wall. In this embodiment the abutment is defined by a shoulder 116 at the end of a base wall portion, defined by the double thickness of components 101a and 101b, which is of greater thickness than the remainder of the wall.

The first wad member also includes a second flange portion 117 which extends towards the end closure 104 and forms a border to the shot chamber 106 which is thicker at the base to withstand the greater shot pressures in this area. The first and second flanges have a continuous outer cylindrical surface of not less than 12 mm, sufficient to allow bridging of the gap between the end of the cartridge and the entry to the barrel, thus reducing gas losses.

In order to minimize friction, space is provided between the cork 112 and the inner wall of the first wad member 105, and between the outer wall of the first wad member and the case 101 inner wall which tapers to its greatest diameter at the closure. These spaces allow the first wad member to expand under the initial pressure without the full pressure being applied between the first wad member and the case. Both case and first wad member also normally contain slip agents which reduce friction.

The second wad member 108 comprises a web 118 and guiding flanges 119 and may include a central stud 132. The flange 119 facing the propellant provides initial sealing. The upper flange provides easy entry into the first wad cavity 115. The upper flange and the stud carry the force to the first wad web

118 with a degree of cushioning.

The second wad member 108 is initially located, preferably as an interference fit, at a predetermined position over the propellant. Depending upon the propellant used and its quantity, the second wad member may in certain instances make contact with the propellant but it should preferably not place the propellant under any significant pressure. Pressure may be applied and gives a functional performance but regularity is sacrificed.

At ignition the second wad member, during the first 20 μs moves only a fraction of a mm due to its mass. This maintains the ignition chamber volume and thus determines the ignition pressure. The sealing of the second wad member is ensured by its interference fit in the thick walled chamber and/or its extended length lower flange formation which, in preferred cases, gives good sealing against an upwardly directed primer gas. The definition of the ignition pressure has a critical bearing on subsequent events, especially peak pressure. The second wad member then moves during the next 0.1 to 0.2ms into engagement with the first wad member which forces the lip portion 114 into good sealing contact with the case. Until this happens, the second sealing member is still in good contact with the wall of the ignition chamber and sealing is thus safely transferred. The mass of the second wad member and the first wad member has then to start accelerating. This point is regarded as the end of the ignition phase, and can be observed as a change of slope in the pressure/time curve. The size of the ignition chamber has thus an important bearing on the ignition conditions. The second wad member can be positioned initially at different positions in the ignition chamber and this produces greater or lesser ignition pressure. However, a lower second wad member position gives a greater space between it and the first wad member and a greater gas cushion so that the high ignition peak is followed for a short interval by a static or declining pressure. The overall effect on peak pressure of the change in second wad member position is thus moderated and the dominating space is the space beneath the first wad member.

Figure 2 shows an alternative form of second wad member 208 designed to give additional cushioning and a greater radial force thus augmenting ignition. Fig 2b shows the member after ignition.

In the embodiment of Figure 3 the cartridge case wall differs from that in Figure 1 in that the shoulder 316 has a continuous annular recess 320 which receives the lip portion 314 of the first wad member. This system provides good sealing without the use of a sliding second wad member. The action depends upon the shock wave from ignition which forces the recess wall 308 and thus the lip portion 314 of the first wad member into good sealing contact with the case 301, before the gas pressure can arrive at the tip of wall 308. A simple non-sealing disc 321 (Figure 3a) can be used to keep the propellant in position. Alternatively, the embodiments of Figure 1 and Figure 3a can be combined as in Figure 3b.

In the embodiment of Figure 4 the second wad member 408 is a stationary (i.e. non sliding) bursting diaphragm. The wad 408 is inserted on assembly and is held stationary during combustion by the gases acting on its long length and/or by its surface friction. The bursting diaphragm 418 is an integral part of the wad 408. In operation the diaphragm 418 acts to keep the propellant in position, and its resistance up to the point of rupture, augments ignition. To provide good sealing of the first wad member it may be desirable to use the lip embodiment of Figure 3. This can either be provided integral with the case as in Figure 3 or as an extended part of the tube 408 as shown in Figure 4. The wad member 408 can use a wide variety of polymers with predictable bursting strengths e.g. medium or high density polyethelene when the typical thickness of the cross member would be less than 1 mm.

In the embodiment of Figure 5, the cartridge case and first wad member 505 may be as in Figure 1. The sealing member in this embodiment comprises a stretchable membrane 508 of inverted cup shape in which the tube portion is held stationary as in the embodiment of Figure 4. On ignition the sealing member 508 stretches under the action of the expanding combustion gases until it engages the first member and lines the combustion chamber as indicated by the broken line 508′, providing a gas tight seal. As the first wad member 512 moves, the membrane 508 ruptures and collapses, and the gas acts directly on the first wad member.

The membrane 508 may be of any elastic polymer such as rubber or EVA. The case need not have a thickened base section, provided other means (such as a jig) are used to position the first wad member.

Figure 6(a) to (d) show an alternative form of main wad in which no separate cushioning member is used. In Figure 6(a) a first wad member 605 is shown with a cylindrical outer surface and it may be employed in a cartridge as shown in Figure 1, the second sealing member being similar.

The first wad member 605 has a lower flange 613 and web 612 similar to that in Figure 1 but differs by the presence of an inner sleeve 640 within the upper flange or shot cup which extends upwardly from the web 612 with a gap between its outer surface and the inner surface of the upper flange 617 of e.g. less than 1mm or smaller than half the diameter of the shot to be used.

The effect of this design is that the area of shot acted upon initially is reduced. The inner sleeve acts as a sideways cushion, simulating the action of the compression wad, and provides additional thickness at the point of highest shot pressure.

The upper flange of the second wad member, as it enters the first wad cavity causes the driving force to be applied to the outer part of the web 612. Consequently, the webs of the first and second wad members flex towards each other and act as a cushion.

The propellant chamber is longer and the range of positions available for the second member is greater. In order to effect a change in propellant type or to accommodate a change in calibre shot weight or velocity it is only necessary to change the second wad weight or position or stiffness. Whilst the space beneath the first wad member is still a major determinant the position of the second wad member has considerable effect upon its velocity of impact onto the first wad member and thus affects the performance of cushioning and sealing systems.

Various modifications can be made as indicated in Figures 6(b) to 6(f) to alter the cushioning effect.

The lower annular groove in Figure 6(e) increases the surface area against which gas pressure is applied for sealing.

In Figure 6(b) compressible struts or rods 641 may be formed in the lower surface of the web 612. These are compressed to provide a cushioning effect as a stiffer alternative to the bowing of the webs. Likewise, struts or rods 642 (Figure 6(c), (d)) may be formed in the second wad member as an alternative. Alternatively one or more annular projections e.g. arranged concentrically may be employed in place of the rods as shown in Figures 6 (e) and 6(f).

One practical embodiment had the following dimensions. The inner sleeve (640) was 10 mm long, 0.5 mm thick and 13 mm I.D. Web 612 was 1.5 mm thick and wall 605 0.5 mm thick. The advantage of all the cushion systems shown in Figure 6 are their use of simple moulds and thus economy of manufacture.

The principle of Figure 6, i.e. radial cushioning, can be used without an inner sleeve by tapering the upper flange to leave a space between it and the case wall. However, this method requires double acting mould tools. The use of predictable cushioning can be expected to reduce variability by comparison with cork.

A suitable material for the second wad member is low density linear polyethylene but medium density polyethylene is also suitable.

All the embodiments of the invention preferably use a weak closure of which the weak roll turn over shown in Figure 10 is a simple example. However a high degree of commercial acceptance of the normal crimp, which is formed from the case body, may require provision for a similar system but without the crimp's strong resistance.

This may be achieved by the use of a convex domed shape with no plastic deformation on closure. Two forms are proposed as examples.

Figure 7a shows an open case moulded with eight teeth T which when folded in a dome as in Figure 7b lie with their edges touching. The tab at the top of the teeth provides material to spot weld the case.

Figure 8a shows an open case moulded with e.g. 12 to 16 teeth T' which when folded in a dome as in Figure 8b lie with their edges overlapping, but with the visible edges forming a radial pattern. By shaping the visible edges forms of spiral or helix can be produced. The tips of the teeth T' are spot welded together.

The tabs T, T' may be closed snugly around the shot which conforms to the dome shape and does not rattle.

Figure 9 uses a frangible disc with lines of weakness L spot welded to the case so that on ignition the disc folds back in a star shape, remaining attached to the case.

Figure 10 is a conventional disc closure of the roll turn over type but with a much weaker degree of turn over and resistance to opening.

Examples

Firing trials were carried out of all the embodiments. In the trials piezo pressure/time graphs were recorded as the most informative data, which was regularly standardized. Recoil measurements and velocity at the muzzle were also used when appropriate. Recoil figures are expressed as distance of travel of a carriage up a slope. The integral of pressure/time was Computed in real time from the piezo output giving a measure of energy in bar ms. Field trials of patterns and pellet individual energies were used to confirm acceptable embodiments.

Some explanation is necessary of the weight to be attached to different measurements both in these trials and generally.

Peak pressure is a key measurement and pressure measurements are generally direct and meaningful at least up to 50 kilohertz.

The pressure/time integral is the energy applied to the wad but in addition to useful energy it includes friction.

Recoil is a measure of output energy but in addition to useful energy it includes gas losses both past the wad and lost at the muzzle as the wad leaves.

Velocity is usually a measure of the velocity of the leading pellets in the shot string, whose velocity can be three times the velocity of the slowest pellets.

The ratio of leading pellet velocity to average velocity in commercial cartridges can reach 1.5:1. Velocity is thus the most widely used measure of output and the most suspect.

There is at present no unambiguous means of measuring output but measures of recoil, integral and velocity combined provide considerable insight.

Conventional cartridges employ gas leakage by design or accident to reduce friction. This increases recoil and may increase average velocity if optimised. However it usually increases measured velocity, i.e. of leading pellets. The cartridges of Figure 1, which have improved sealing reduce gas leakage and when optimized give high recoil and integral and thus high average velocity. However the extra damping reduces measured velocity.

The following examples and Figures 11 to 19 show the performance of the embodiments together with commercial comparisons.

Example 1

A cartridge was constructed to Figure 1 using a cork wad of 9 mm, a case of base (102) thickness of 6 mm, ignition chamber length of 19 mm and a base wall thickness of 2 mm. The first wad member had a lower flange 113 of 7 mm thickness and web of 4 mm thickness. The second wad member was 0.75g of similar construction to Figure 1 but without the upper flange. The top of the second wad member was 3.8 mm from the shoulder 116. The propellant was 1.35g of S4. flake. The pressure time curve is shown in Figure 11. The internal energy was 515 bar m.s., the recoil 644 mm, and the velocity 375 m/s. The recoil, integral and target energy tests all suggested that this cartridge had equal or superior average velocity to other cartridges in which the measured velocity was 390 m/s.

Example 2

A cartridge was constructed to Figure 6d using no cork and 7 cushioning rods in the first was member. The design aimed at low damping and merely adequate sealing. The propellant chamber was 26mm and the first wad member flange 116 was 5mm with a web of 2mm thickness. The second wad member was of 0.6g. The top of the second wad member was 7.6mm from the shoulder 116. 1.35g of S4 flake propellant was used and the pressure/time curve is shown in Figure 12. The integral energy was 500 bar m.s., the recoil 646 mm and the velocity 390 m/s. Field trials of pellet energy indicate the same average velocity as Example 1. Ten firings were carried out and the range of peak pressure variability is shown in Figure 12 as ±2%.

Comparative Example 1

From a number of commercial cartridges one was selected which operated at the same peak pressure as Examples 1 and 2. The propellant was 1.63g of single base equivalent in calorific value to 1.42g of S4 flake. The pressure/time curve is shown in Figure 13. The integral energy was 495 bar, the recoil 648mm and the velocity 390 m/s. The variability within a batch of 10 is shown and amounts to 4.5%, and the band B of peak pressures of different batches over a year is also shown. This cartridge represents the better quality among those available; e.g. a widely used cartridge has 1.65g of double base propellant and poorer performance.

Example 3

A cartridge was constructed to Figure 6d and Example 2 but using a lighter 0.38g second wad member, to show the effect on ignition and peak pressure. The pressure/time curve is shown in Figure 14. The integral energy was 490 bar m.s., the recoil 632mm and the velocity 386 m/s, whilst peak pressure was reduced from 560 bars to 530 bars m.s.

Example 4

A cartridge was constructed to Figure 6e using a 0.65g second wad member and a 2.5mm lower flange 613 to the first wad member. The second wad member was 4mm thick at the centre and the lower groove was 2mm deep. The tip of the second wad member was 7.6mm from the shoulder 116. This design was for a low recoil cartridge for first barrel clay target work. The propellant was binary double base propellant of 1.3g. The pressure/time curve is shown in Figure 15. The integral was 470 bar m.s, the recoil 610mm, and the velocity 380 m/s.

Example 5

A cartridge was constructed to Figure 4. The case, first wad member and cork were as in Figure 1. The bursting diaphragm was 0.7g of M.D.P.E. with a length of 20mm and a web thickness of 0.7mm, positioned with a 2mm overlap on the first wad member flange 414. The propellant was 1.2g of S4 type. The pressure/time curve is shown in Figure 16. The integral energy was 423 bar m.s. The combustion, shown by the peak pressure of 600 bars was satisfactory. The tube of the second sealing member was retained in the case.

Example 6

A cartridge was constructed to Figure 5 but with the case and first wad member as in Figure 1. The membrane was a cup of 40% EVA of weight 0.7g. and lmm wall thickness. The propellant was 1.2g of S4 type. The pressure/time curve is shown in Figure 17. The integral was 416 bar m.s. and the peak pressure was 560 bars. The membrane, punctured, was retained in the case.

Example 7

Two cartridges were constructed to Figure

1 with a paper end closure on one and an iris closure (Figure 8a) on the other. The purpose of the test was to demonstrate the small effect on peak pressure of introducing the iris closure. The propellant was 1.35g of S4 and the pressure/time curves are shown in Figure 18. The difference (Δp) in the peak pressure due to the iris was 50 bars or 8%.

Comparative Example 2

Two commercial cartridges of the same type were tested, one with a normal crimp and the second with the crimp opened and the shot retained by paper. The results are shown in Figure 19. The drop in peak pressure (Δp) without the crimp was 210 bars or 31%. This example shows a less extreme effect than some cartridges where removal of the crimp reduced pressure by 400 bars (a missfire).

Conclusions

The Examples demonstrate a wide variety of cartridges designed and constructed without a crimp or other strong closure and using normal propellant of less than normal quantity, and have been shown to give satisfactory combustion and performance with resultant improved efficiency, both in terms of propellant calorific value and in terms of manufacturing cost.

Closures integral with the case have been designed and constructed which are commercially attractive and yet meet the requirement for a weak closure.

Simple injection moulding processes resulting in weak cases have been shown to work satisfactorily without rupture.

The re-design of the obturator with fixed component location gives a wide range of design choices to meet different calibre shot weight and velocity requirements.

Of greater importance, the reproducibility of the performance from cartridge to cartridge predicted by the inventive design is shown to be borne out in practice and can be expected to improve under more closely controlled manufacturing conditions.

CLAIMS

1. A shot gun cartridge exhibiting a peak pressure within the normal range (400 to 700 bars) characterised by an end closure which opens under a negligible to weak force such that the peak pressure developed in the absence of the closure is lower by 20% or less than that developed with the closure in place.

2. A cartridge according to claim 1 wherein the peak pressure is lower by 10% or less.

3. A cartridge according to claim 1 or claim 2 wherein the closure is formed of material integral with the cartridge case.

4. A cartridge according to claim 3 in which the end closure is formed from teeth moulded or cut in the case mouth and folded inwards in a dome shape so that adjacent teeth meet along generally coincident lines, the teeth being spot welded or spot bonded together at the centre.

5. A cartridge according to claim 3 in which the end closure is formed from teeth moulded or cut in the case mouth and folded inwards in a dome so that adjacent teeth overlap, the teeth being spot welded or spot bonded at the centre.

6. A cartridge according to claim 5 wherein the visible edge of the tabs is shaped to provide a radial or spiral formation.

7. A cartridge according to claim 1 or claim 2 wherein the end closure is formed by a frangible disc.

8. A cartridge according to claim 6 wherein the disc is spot welded or bonded to the end of the open cartridge.

9. A cartridge according to claim 1 or claim 2 wherein the end closure is formed by a disc which is removed by exit of the shot, the disc being held in place by deformation of material of the case or by spot welding or spot bonding of the open end of the case.

10. A cartridge according to any of claims 3 to 9 comprising case having a cylindrical wall and a base holding a percussion ignition means, the cartridge including an end closure and an obturating means having an upper face defining with the end closure a shot chamber containing shot, and having a lower face defining with the base a space containing propellant in communication with the ignition means, characterised in that the end closure is of fixed position and defines a fixed volume and the obturating means includes a first wad member having an upper face bounding the shot chamber and which is located at a fixed position within the cartridge case so that its lower face determines a combustion chamber of predetermined volume, the position of the shot being fixed between the upper face of the obturating means (including any spacer member) and the end closure.

11. A cartridge according to claim 10 including a first wad member which is located so as to determine the upper wall of a combustion chamber of greater volume than that occupied by the propellant and a sealing member which is arranged to confine the propellant within an ignition chamber at the lower end of the combustion chamber prior to ignition.

12. A cartridge according to claim 11 wherein the first wad member comprises a web having a first flange portion extending towards the sealing member and terminating in a lip portion, the web and flange portion defining a seal cavity and the sealing member is arranged to engage the lip portion upon ignition.

13. A cartridge according to claim 12 wherein the sealing member is a second wad member spaced from the first wad member within the propellant chamber and fixed within

the cartridge as an interference fit.

14. A cartridge according to claim 13 wherein the second wad member operates by sliding, upon ignition, along the cartridge case from an initial position spaced from the first wad member to a final position within the seal cavity, causing the outward expansion and pressing of the lip portion.

15. A cartridge according to any of claims 11 to 14 wherein the sealing member in its initial location does not place the propellant under significant pressure.

16. A cartridge according to any of claims 11 to 15 wherein the sealing member includes a wall portion forming an inner lining to the base portion of the cartridge wall and extending from a base end surrounding at least part of the propellant, and a web portion formed as a bursting diaphragm.

17. A cartridge according to any preceding claim wherein the base is formed with an extraction rim and means for receiving a cap and wherein a base outer section, including the extraction rim and an adjacent wall outer surface portion, is formed separately from the remainder of the case and joined thereto under heat and pressure.

18. A cartridge according to claim 17 wherein the base outer section and the said remainder are formed by injection moulding.

19. A cartridge according to claim 18 wherein the case is injection moulded in a single cycle, the base outer section being first formed and the remainder formed against it.

20. A cartridge according to any of claims 17 to 19 wherein the base outer section is of greater tensile and/or impact strength than the said remainder.

21. A cartridge according to any of claims 17 to 20 wherein the base outer section is of linear medium density polyethyleneor high density polyethelene.

22. A cartridge according to claim 21 wherein the said remainder is of material comprising low density, medium density or linear low density or linear medium density polyethelene.

23. A cartridge according to any of claims 17 to 22 wherein the said remainder is biologically degradable.

24. A cartridge according to any of claims 17 to 23 wherein the said remainder is of material incorporating starch in an amount up to 40% by weight.

25. A cartridge according to any of claims 17 to 24 wherein the base outer section is of different colour from the said remainder.

26. A cartridge according to any of claims 17 to 25 wherein the cartridge wall portion between the open end and the base outer section has a tensile strength less than (?4000 psi).

27. A cartridge according to any of claims 17 to 26 wherein a base wall portion coextensive with the base outer section is of greater thickness than the remaining end portion of the cartridges.

28. A cartridge according to claim 27 wherein the base wall portion has an impact strength of 15 to 30 joules/cm^2.

29. A cartridge according to claim 27 or 28 including a first wad member located against the said step so that its lower face determines a combustion chamber of predetermined volume.

30. A cartridge according to claim 29 including a second wad member positioned as an interference fit against the thick wall portion of the case wall.

31. A cartridge according to claim 30 wherein the second wad member is located so as not to place propellant under pressure.

32. A cartridge according to claim 30 or 31 wherein the first and second wad members are dimensioned in that the second wad member slides upon ignition to fit within a sealing cavity in the first wad member.

33. A cartridge according to any preceding claim in which the first wad member contains no compressible wad or other filler member in the shot cup and is formed with an inner sleeve portion extending upwardly from the web for part of the length of the wad, the inner sleeve being spaced from the inner wall of the wad member by a distance less than half the diameter of a shot pellet.

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