

**Metallic solid projectile, tool arrangement and method for
producing metallic solid projectiles**

The invention relates to a metallic solid projectile for practice cartridges, in particular for use on police firing ranges. The invention also concerns a tool arrangement for the production of metallic solid projectiles for training cartridges. The invention also includes a method for producing metallic solid projectiles for practice cartridges. For use on police shooting ranges, projectiles for training cartridges must meet the requirements of the "Technical Directive (TR) Cartridge 9 mm x 19, Reduced Pollutant" (in particular: as of September 2009), with the proviso that for training cartridges some of the requirements of the aforementioned technical directive for training cartridges, inter alia with regard to the end-ballistic effect, need not be met.

A standard solid projectile for practice cartridges is known from EP 2 498 045 A1. The conventional solid projectile consists of a curved ogive at the front and a cylindrical area adjacent to it. In the area of the curved ogive, the known solid projectile is equipped with an ogival wall which circumferentially bounds an ogival cavity and is formed on the inside with predetermined breaking points in the form of notches and edges. These predetermined breaking points serve as predetermined zones for initiating or promoting material failure. They facilitate the folding of the projectile solid material with the formation of cracks in the outer skin of the ogive when the projectile strikes a target at the front. When the projectile hits its target according to EP 2 498 045 A1, it should deform ("mushroom up"). When the projectile is deformed, its kinetic energy is converted into deformation energy. The conversion of kinetic energy into deformation energy should take place as quickly as possible in practice cartridge projectiles in order to prevent the projectile from remaining with a sufficient amount of kinetic energy to penetrate in particular protective vests, for example police protective vests. In the case of the well-known solid projectile for practice cartridges, it has been found to be disadvantageous that the crack effect of the predetermined breaking points can cause the projectile to splinter on impact with the target or a hard surface, such as the wall of a shooting range. The splintering of a practice projectile can result in dangerous cross impact splinters for practicing shooters.

Embodiments of the invention seek to provide a metallic solid projectile for practice cartridges, which may overcome the disadvantages of the state of the art, in particular in compliance with

the "Technical Guideline (TR) Cartridge 9 mm x 19, reduced pollutant", and in which the splintering of the solid projectile on impact with a hard surface may be avoided.

An aspect of the present disclosure provides a metallic solid projectile for practice cartridges, in particular for use on preferably police shooting ranges, wherein the solid projectile comprises an ogival portion at the front side and a cylinder portion for holding the solid projectile in a cartridge case and defines a projectile length in the axial direction, wherein the ogival portion comprises an ogival wall and a rotationally symmetrical ogival cavity circumferentially bounded by the ogival wall, characterized in that a fully cylindrical stem portion of the solid projectile extends in the axial direction over less than 45% of the projectile length.

Another aspect of the present disclosure provides a tool arrangement for producing metallic solid projectiles for practice cartridges, preferably with a rotationally symmetrical ogival cavity, comprising a preform press having a hollow cylindrical projectile blank receptacle which is bounded in the axial direction by a bottom side, a preform punch, having a preform section which tapers in the axial direction relative to a front surface, preferably at least in sections conically, in particular in the form of a truncated cone, and in particular rotationally symmetrical, the preform portion being movable relative to the bottom side for forming a projectile blank to a preform end position in which the preform punch, the bottom side and the projectile blank receptacle define a preform cavity for the projectile blank, characterized in that in the preform end position, an axial distance between the bottom side and the front surface is less than 45% of a maximum height of the cavity in the axial direction.

Another aspect of the present disclosure provides a method for producing metallic solid projectiles for practice cartridges, preferably with a rotationally symmetrical ogive cavity, in which a metal blank formed in particular from cut-to-length metal wire is provided, preferably with a cylindrical outer surface, characterized in that, in a preforming step, the metal blank is formed into a projectile blank with a sleeve-shaped portion which, at the end of the preforming step, extends over more than half of the greatest axial blank height, in particular the sleeve-shaped portion being formed with a preferably continuously tapering inner contour.

Accordingly, a metallic solid projectile is provided for practice cartridges, in particular for use on preferably police shooting ranges, wherein the solid projectile comprises a front-side ogival portion and a cylinder portion for holding the solid projectile in a cartridge case and defines a projectile length in the axial direction. Solid projectiles differ from partial jacket projectiles and solid jacket projectiles in that a solid projectile is formed in one piece, in particular from a homogeneous material. The solid projectile is intended in particular for practice cartridges for use in handguns, i.e. revolvers, submachine guns and/or pistols. A metallic solid projectile may also be provided for training cartridges for rifles. Preferably the solid projectile is intended for practice cartridges up to a caliber of 20 mm, in particular up to a caliber of 12 mm. Cartridges usually consist of a projectile, a cartridge case, propellant powder and a primer. The projectile is the object fired from the weapon. The weight of a projectile can be between 3g and 20g, in particular between 5g and 15g, preferably between 5.5g and 9g, in particular preferably between 6.0g and 6.3g, for example 6.1g, for a cartridge caliber of 9 mm x 19 (Luger caliber or Para caliber), when using which the penetration of a protective vest is to be ruled out. Due to their weight and shape, the projectiles of standard Luger caliber cartridges reach muzzle velocities of 340 mm/sec. or more at 9 mm. The material of the solid projectile is preferably lead-free and/or lead alloy-free. The metal of the solid projectile is preferably copper. In particular, at least 95%, at least 99% or at least 99.9% of the metal of the solid projectile consists of copper. The particularly uncoated projectile consists particularly preferably of pure copper (Cu-ETP), preferably with a specific weight of 8.93 g/cm³, in particular of CU-ETP1 according to DIN EN1977 with at least 99.9% copper content and less than 100 ppm oxygen. According to less preferred configurations, the metal material of the solid projectile may be brass (i.e. a mixture of copper and zinc such as tombac). The specific weight of copper is 8.9g/ccm. The specific weight of zinc is 7.2 g/ccm. The specific weight of brass is at least 8.3 g/ccm, while the specific weight of tombak is about 8.6 g/ccm.

Preferably the cylinder section of the solid projectile is directly adjacent to the ogival section, in particular the arcuate ogival section. The ogival section arranged at the front in the flight direction of the solid projectile can be described as the front side. The rear cylinder section of the solid projectile in the flight direction of the projectile can be designated as the foot side or the rear side. The ogival section is arranged axially in front of the cylinder section of the solid projectile. The cylinder section preferably has a circular outer contour in cross-section. The shape of the cylinder section preferably corresponds to a vertical or straight circular cylinder.

The rear end of the cylinder section may have a chamfered section to facilitate the insertion of the solid projectile into a neck of a cartridge case and/or to form a particularly aerodynamic rear end (generally referred to as the "boat tail"). Preferably, the metallic solid projectile consists of the frontal ogival section and the rear cylindrical section.

In a strictly geometric sense, an ogive is a form in three-dimensional space that is created by the rotational body of the intersection of two circular arcs. Based on the geometric term, similarly shaped profiles, for example of ballistic projectile tips, are called in longitudinal section, which should have as little air resistance as possible when moving. Ogive can be understood as a streamlined body of revolution, which can be pointed or rounded (flattened) at the front.

The ogival section has an ogival wall and a rotationally symmetrical ogival cavity circumferentially bounded by the ogival wall. The ogival cavity of the hollow projectile according to the invention allows the projectile to deform in the form of a compression on impact with a target or other resistance. When the projectile is compressed, its kinetic energy is quickly converted into deformation energy. When the projectile is compressed, the tip of the projectile deforms only in the axial direction, preferably relative to the cylinder section. In particular, when the projectile hits a flat resistance perpendicularly, there is preferably no deformation of the projectile tip in the radial direction across the diameter of the undeformed cylinder section. The ogival cavity is preferably empty, i.e. only filled with ambient air. An inner contour encompassing the ogival cavity, defined by the ogival wall, is preferably formed step-free and/or uninterrupted in the circumferential direction and/or has only rounded edges. An outer side of the ogival defined by the ogival wall is preferably formed without steps in the circumferential direction and/or has a constant wall thickness circumferentially, in particular completely.

Preferably the projectile at or near its tip is harder than at the rear. For example, the tip may have a hardness between 110 HV0.5 to 200 HV0.5, in particular 120 HV0.5 to 160 HV0.5, preferably 130 HV0.5 to 150 HV0.5. The cylinder section may have a low hardness, for example a hardness between 50 HV0.5 to 160 HV0.5, in particular 75 HV0.5 to 155 HV0.5, preferably 85 HV0.5 to 150 HV0.5.

According to a first aspect of the invention, a fully cylindrical, i.e. massive, stem section of the solid projectile extends in axial direction over less than 45%, less than 40%, less than 30%, less than 20%, less than 10%, less than 5%, or over 0%, preferably between 40% and 0%, in particular between 20% and 10% or 0%, of the projectile length. Compared to the solid projectile known from EP 2 498 045 A1, in which an ogive cavity in the area of the frontal curved ogive is located only in the tip area of the projectile, so that behind the ogive cavity a long,

massive stem section is formed, it has surprisingly proved to be advantageous to form a solid projectile for training cartridges with a significantly shortened stem section or without a stem section at all: Surprisingly, this has not reduced the stability of the projectile to such an extent that there is a risk of fragmentation. Nor is the self-loading function of conventional semi-automatic handguns impaired. The reduction of the axial height of a fully cylindrical stem section in accordance with the invention significantly increases its upsetting tendency, so that on impact of the projectile its kinetic energy can be converted extremely quickly and effectively into deformation energy. The safety of the practicing shooter and other persons on the shooting range is thus considerably improved.

According to a second aspect of the invention which can be combined with the above mentioned, the invention concerns a metallic solid projectile for practice cartridges in particular for use on preferably police shooting ranges, the solid projectile comprising a frontal ogive portion and a cylinder portion for holding the solid projectile in a cartridge case. The ogival section and/or the cylinder section can be configured as described above. In contrast to hunting projectiles, for example, in which the mushrooming of the projectile is to be accompanied by a spreading of the projectile in the shape of a petal, it may be desirable for practice cartridges to be accompanied by a substantially symmetrical compression or folding radially inwards without a spreading of the petal in the shape of a petal in order to avoid splintering. A rotationally symmetric compression or folding without spreading of the solid projectile is guaranteed by the rotation symmetry of the ogival cavity, especially free of steps and/or changes of the wall thickness of the ogival wall in circumferential direction. The ogival cavity may preferably be bell-shaped in cross-section.

According to the second aspect of the invention, the ogival cavity has a bottom. The bottom of the ogival cavity is preferably located at the rear or far from the front of the projectile. Starting from the bottom of the ogival cavity, a shaft extends into the cylinder section according to the second aspect of the invention. The shaft extending into the cylinder section may have a microchannel and/or a deformation cavity. The deformation cavity of the chamber may be at least sectionally cylindrical and/or at least sectionally conical with tapered ends. Preferably, the deformation cavity is heart-shaped or ideally conical.

In accordance with the second aspect of the invention, a solid projectile is equipped with an interior space which, in addition to the ogival cavity, has a further deformation cavity extending in the axial direction in the rear, which promotes radial impact deformation of the practice cartridge solid projectile over much of the length of the projectile or even the entire length of the projectile. The shaft extending from the bottom of the ogival cavity into the cylinder section can also be described as a gap or throat. For example, a throat-like shaft can be

realized by a parabolic funnel-shaped tapering starting from the ogival cavity, which provides a capillary-like microchannel. A capillary-like microchannel preferably has a microscopic opening width, especially smaller than 1 mm or smaller than 1/10 mm. Along a capillary-like microchannel or capillary section, the shaft is constricted or constricted at least in sections in such a way that the inner wall of the shaft is formed into a linear constriction. A fusion of the metal material of the solid projectile transversely to its axial direction, in particular by removing the metal grain boundaries, preferably does not take place along the capillary section.

According to a preferred configuration of the invention, the ogival wall has an ogival wall thickness and the solid projectile forms an annular deformation sleeve wall in the cylinder section in the axial direction, at least in sections, which has a deformation sleeve wall thickness. The deformation sleeve wall thickness is greater than the ogival wall thickness. Preferably, the ogival wall extends over at least 50%, preferably at least 55% and/or at most 75%, preferably at most 60%, of the projectile length. The axial extension of the deformation sleeve wall preferably extends between the bottom of the ogival cavity and, if present, the rear section of the solid projectile or the lowest end or foot or tail of the solid projectile. The inner side of the deformation sleeve wall circumferentially borders a preferably rotationally symmetrical deformation cavity and/or microchannel. The inner side of the ring-shaped deformation sleeve wall can have a diagonal clear width, preferably a clear diameter width, which changes particularly in axial direction. In a microchannel, the clear width can extend diagonally between the opposite deformation sleeve inner sides via 10 μm and 1 μm , for example between 10 μm and 500 μm or approximately via 100 μm . A microchannel may also have a capillary section with an average clear width of less than 10 μm or 1 μm . The rear or foot end of the shaft is preferably dome-shaped or blind hole-shaped at the flat butt end.

In the ogival cavity, the clear width can be up to several millimetres. For example, an ogive cavity can have a clear width of up to 8 mm, preferably up to 7.5 mm, in particular about 7.46 mm, in a solid projectile of the 9 mm Luger caliber in accordance with the invention.

In particular, the mean deformation sleeve thickness (determined in radial direction over the height of the deformation sleeve section in axial direction) can be greater than the mean ogival wall thickness (determined in radial direction over the axial height of the ogival section). Preferably the smallest deformation sleeve wall thickness is greater than the largest ogival wall thickness. Preferably, the largest or mean ogival wall thickness in particular is smaller than half the largest outer radius of the solid projectile, in particular larger than half the solid projectile caliber. Alternatively or additionally, the deformation sleeve wall thickness is less than or equal to the radius of the solid projectile, in particular less than or equal to half the caliber of the solid projectile. In particular, the ogival wall thickness may be less

than $1/4$ of the largest radius of the solid projectile, less than $1/8$ or less than $1/10$ of half the radius of the solid projectile. In particular, the ogival wall thickness shall be less than 3 mm, less than 2 mm, less than 1,5 mm, less than 1 mm or less than 0,8 mm. In particular, the ogival wall thickness is greater than 0,1 mm, greater than 0,3 mm, greater than 0,5 mm or greater than 1 mm. Preferably, the mean ogival wall thickness is between 1.0 mm and 1.5 mm.

According to a preferred configuration of the invention, the solid projectile is blunt at the front-side. A blunt solid projectile can have a flattened projectile front-end, for example. Preferably, the opening angle of the blunt solid projectile can be greater than 150° at its frontmost point, which can be designated as the apex. The opening angle of the blunt solid projectile at its top is preferably between 150° and 180° , especially at about 180° . One millimetre axially from the tip of a blunt solid projectile, an opening angle tangent (of the outside of the projectile) can be greater than 120° and, in particular, lie between 120° and 140° , for example at about 130° . At a distance of 2 mm in the axial direction from the blunt tip of a solid projectile, an opening angle tangent (a second point on the outside of the projectile) can be greater than 90° , e.g. between 90° and 110° , especially at about 100° .

In a preferred configuration of the invention, the solid projectile has a front-sided opening that leads into the ogival cavity. A smallest or inner diameter of the opening is larger than the average or smallest ogival wall thickness and/or is larger than the opening width of a micro-channel and/or larger than 1 mm, 2 mm or even 3 mm. Preferably the opening width is smaller than 7 mm, smaller than 5 mm or smaller than 4 mm. Solid projectiles with an opening width at the front of approximately 1.3 mm $\pm$ 0.15 mm are particularly preferred. Surprisingly, such a dimension has resulted in particularly good aerodynamics and an advantageous mushrooming behaviour, especially for solid copper projectiles.

In a preferred configuration of the invention, the fully cylindrical stem section extends in the axial direction over less than 3 mm, less than 2 mm, or less than 1 mm. Alternatively or additionally, a calotte may be recessed at the rear end of the solid projectile, which may, for example, be dome-shaped, cone-shaped or frustoconical. The calotte is preferably coaxial and/or concentric with the axis of symmetry or rotation A of the solid projectile. If a calotte is present, the solid stem height extends between its projectile frontal apex and the rear end of the shaft, which forms the microchannel and/or deformation cavity. Preferably the calotte is frustoconical or conical with an opening angle between 100° and 140° , preferably about 100° , and/or a calotte depth in the axial direction of at least 0.5 mm or at least 1 mm and at most 2.5 mm, preferably at most 2 mm, in particular about 1.5 mm. In particular, the calotte is rotationally symmetrical. A chamfer, preferably a frustoconical chamfer, with an opening angle between 30° and 90° , in particular about 60° , and a chamfer height of less than 2 mm,

preferably less than 1 mm, in particular about 0.5 mm, can be formed on the radial outside at the rear end of the cylinder section. The calotte volume shall be less than 15 mm³, preferably less than 10 mm³, in particular approximately 9,8 mm³.

According to a preferred configuration of the invention, an inner contour surrounding the ogival cavity, which is defined in particular by the ogival wall, is completely rounded in the axial direction, preferably without steps, and/or has only rounded edges. The inner contour of the ogival cavity is completely rounded in the axial direction without any steps and/or without any cracks, so that there is preferably no pronounced notching effect.

According to a preferred configuration, the solid projectile corresponds to the 9 mm Luger caliber. If the outside diameter of the projectile is 9.02 mm and the solid projectile is 9 mm Luger caliber, the volume of the ogival cavity and, where appropriate, of the frontal opening and/or a deformation cavity and/or a microchannel may be between 150 mm³ and 200 mm³, preferably between 185 mm³ and 192 mm³, in particular around 189 mm³. The mass of a 9 mm Luger caliber solid projectile according to the invention can be approximately 6.1 g.

In the case of a preferred configuration of a solid projectile in accordance with the invention, this corresponds to one of calibers .357 Mag. and may have an outside diameter of more than 9.12 mm. In the case of an invented solid projectile with .357 Mag. caliber, the cavity volume of the ogive cavity and, where appropriate, the cavity of the front opening and/or the deformation cavity and/or a microchannel may be between 150 mm³ and 220 mm³, in particular approximately 196 mm³.

In a preferred configuration, the invented solid projectile corresponds to the .40 S&W caliber. An invention solid projectile of .40 S&W caliber may have an outer diameter of 10.17 mm. For a solid projectile of caliber .40 S&W according to the invention, the cavity volume can be between 250 mm³ and 290 mm³, preferably between 260 mm³ and 280 mm³, in particular between 270 mm³ and 273 mm³, for example about 271.5 mm³.

In a preferred implementation of the invention, the solid projectile corresponds to the caliber .44 Rem. Mag. A solid projectile of caliber .44 Rem. according to the invention can have an outer diameter of 10.97 mm. In the case of a solid projectile of caliber .44 Rem. Mag. according to the invention, the cavity volume of the ogive cavity and, if applicable, the cavity of the frontal projectile opening and/or the deformation cavity and/or the microchannel can be between 320 mm³ and 360 mm³ and, in particular, between 330 mm³ and 350 mm³, preferably between 339 mm³ and 343 mm³, further preferably between 340 mm³ and 341 mm³, in particular about 340.5 mm³.

In a preferred configuration of the invention, the solid projectile corresponds to the .45 ACP caliber. In the case of a caliber .45 ACP projectile according to the invention, the outside diameter of the projectile may be 11.48 mm. In the case of a solid .45 ACP caliber projectile according to the invention, a cavity volume of the ogive cavity and, where appropriate, an opening volume of a frontal projectile opening and/or a deformation cavity and/or a micro-channel may be between 370 mm³ and 410 mm³, preferably between 380 mm³ and 400 mm³, in particular between 388 and 393 mm³, in particular between 389 mm³ and 391 mm³, preferably about 390,5 mm³.

According to the invention, the metallic solid projectile for practice cartridges has an ogival section with an ogival wall and a rotationally symmetrical ogival cavity which is circumferentially limited by the ogival wall, especially in the radial direction and preferably completely circumferentially.

The invention also concerns a tool arrangement, in particular a press arrangement, for producing metallic solid projectiles for practice cartridges, preferably with a rotationally symmetrical ogival cavity, in particular for police practice shooting ranges. The tool arrangement in accordance with the invention is especially configured for the production of a metallic solid projectile as described above. An inventive tool arrangement comprises a preforming press or a preforming station with a hollow-cylindrical, in particular ideal-cylindrical, projectile blank receiving means or preforming die, which is bounded in the axial direction by a bottom side, in particular a rear punch, a preforming punch, having a preforming section, in particular rotationally symmetrical, which tapers in the axial direction to a front surface preferably at least in sections conically, in particular in the form of a truncated cone. In particular, the preform punch also has a guide section which is complementary in radial direction to the shape of the projectile blank receiving means and in particular adjoins the preform section in axial direction.

According to the invention, the preform section is movable relative to the bottom side for forming a projectile blank up to a preform end position in which the preform punch, the bottom side and the projectile blank receiving means define a preform cavity for the preformed projectile blank (first stage). The preform press may include a drive for pressing the preform section into a projectile blank located in the projectile blank receptacle. The bottom side of the preforming station is preferably realized by a rear punch, which is movable in axial direction relative to the preforming punch and/or the projectile blank receptacle.

According to the invention, in the preform final position, an axial distance between the bottom side of the preform press projectile blank receptacle (the bottom side of the die of the

preform station) and the front surface of the preform punch is less than 45%, in particular less than 40%, less than 30%, less than 20%, less than 10% or less than 5%, of a maximum cavity height in axial direction. If the preform portion of the preform die is frustoconical, the largest height of the cavity may extend between the base of the frustoconical of the preform die and a portion of the bottom side of the preform press projectile blank receptacle furthest therefrom, preferably the top face of the rear punch.

In accordance with a preferred configuration of an inventive tool arrangement, the tool arrangement also includes an inner contour forming press. The inner contour forming press or inner contour station has a hollow cylindrical, in particular ideal cylindrical, projectile blank receptacle or inner contour outer die, which is axially limited by an (inner contour) bottom side, in particular a rear punch. The inner contour forming press may comprise the same projectile blank receptacle and/or the same bottom side, preferably the same rear punch, as the preforming press. The inner contour forming press may comprise a different projectile blank receptacle and/or a different bottom side, preferably a different rear punch, than the preforming press. The inner contour forming press comprises an inner contour forming punch having an inner contour forming section extending axially to a front surface of the inner contour forming punch. The inner contour forming section is movable relative to the bottom side of the inner contour forming press for forming the projectile blank to an inner contour forming end position in which the inner contour forming punch, bottom side and projectile blank receptacle define an inner contour forming cavity for the inner contour formed projectile blank (second stage). The bottom side of the inner contour forming station is preferably realized by a rear punch, which is movable in axial direction relative to the inner contour forming punch and/or to the projectile blank receptacle.

The inner contour forming punch can have an inner contour forming punch guide section which is formed in the radial direction complementary to the projectile blank receptacle of the inner contour press and which in particular adjoins the inner contour forming section in the axial direction. The inner contour forming press can have a drive for pressing the inner contour forming section into a projectile blank arranged in the projectile blank receptacle. The drive of the inner contour forming press can be the same or a different drive than that of the preforming press.

According to the preferred configuration of the tool arrangement according to the invention, an axial distance between the bottom and the front surface of the inner contour press is greater than the axial distance between the bottom of the preform press and the front surface of the preform punch in the preform end position, especially in the inner contour final position. The use of different preform pressing and inner contour pressing tools allows a projec-

tile blank to be formed into a preform step without cutting, in particular by cold forming at least in sections or completely in the form of a sleeve by punching in or out, and a predefined inner contour to be introduced into the projectile blank in an inner contour forming step. By using different tools, the desired inner contours can be produced with particular precision, in particular by introducing the desired preload.

In accordance with a preferred further configuration of a press arrangement according to the invention, the front surface of the inner contour forming punch can be formed as a blunt cone tip, in particular with rounded front rim edges. A blunt cone tip can have an opening angle between 140° and 180° , for example between 150° and 170° , in particular about 160° . If an inner contour forming punch is provided with a blunt cone tip and a sleeve section with an essentially cylindrical outer contour (or a rounded front edge), it may be referred to as a round punch. The rounded front edge may have a radius of curvature of at least 0.5 mm, at least 1 mm, at least 1.5 mm or at least 2 mm and/or at most 10 mm, at most 5 mm, at most 3 mm or at most 2.5 mm. Preferably an ogival radius of curvature near the tip is between 1 mm and 5 mm, preferably between 2 mm and 4 mm, in particular about 3,1 mm. An ogival radius of curvature close to the cylinder section must be between 10 mm and 50 mm, preferably between 20 mm and 30 mm, in particular approximately 23,5 mm.

According to a preferred further configuration of a tool arrangement according to the invention, the inner contour shaped section can be formed in axial direction section by section, preferably completely, as a sleeve shaped section with essentially cylindrical or frustoconical outer contour. A substantially cylindrical outer contour may have a demolding slope of less than 1° , in particular less than $0,5^\circ$. For example, a substantially cylindrical sleeve mold section may have a cylinder radius difference of about 0.03 mm at a cylinder length of about 6 mm. The inner contour forming section may, in particular adjacent to a possibly provided guide section of the inner contour forming punch, for example as described above, have a frustoconical transition section extending radially from the inner contour forming section to the guide section, the transition section preferably having an opening angle between 60° and 120° , in particular 90° .

In a preferred further configuration of the inventive tool arrangement, which can be combined with the previous one or ones, the taper of the preform section of the preform punch is more pointed than the preferably tapered outer contour (or essentially cylindrical outer contour) of the inner contour forming section, in particular of the sleeve forming section of the inner contour forming punch. It is clear that a more pointed contour has a smaller opening angle than a blunter outer contour. According to this preferred further configuration of the inventive tool arrangement, the inner contour forming punch is shorter and blunter in rela-

tion to the preform punch. The preform punch is preferably truncated cone shaped, especially with a flat front surface and rounded front surface edge, and longer in axial direction than the length of the inner contour punch. The inner contour forming punch can preferably be essentially fully cylindrical with a blunt front surface and a rounded front edge. The inner contour punch is preferably rotationally symmetrical. The forming punch allows the projectile blank to be pierced largely or completely in the axial direction. The inner contour forming punch allows a part of the material of the solid projectile blank to be compressed to form a shoulder and a sleeve section to be formed section by section with a relatively large internal cavity, which can be formed into an ogival cavity with one or more further tools of the tool arrangement.

In accordance with a preferred configuration of a tool arrangement according to the invention, the tool arrangement further comprises a setting press or setting station comprising a hollow cylindrical, in particular ideal cylindrical, metal blank receptacle or setting die, which is delimited in axial direction by a bottom side, which is preferably realized by a rear punch. The die or the metal blank receptacle and the bottom side (setting-rear punch) of the setting press can in turn be different from or the same as the projectile blank receptacle and/or the bottom side of the preforming press and/or the inner contour forming press (preforming and/or inner contour forming rear punch). When the tool arrangement is carried out with setting presses, it also has a setting punch which is movable relative to the bottom side of the setting press for forming a metal blank up to a setting end position in which the setting punch and the projectile blank receptacle form a setting cavity with a predetermined clear width for defining a constant outer diameter, in particular the caliber diameter, of the metal blank. The bottom side of the setting station is preferably realized by a rear punch, which is movable in axial direction relative to the setting punch and/or the die.

Preferably, the setting punch comprises a centering knob coaxial with the metal blank receptacle and/or the bottom side and projecting axially into the cavity for introducing a central, coaxial centering recess into the metal blank. Alternatively or in addition, the bottom side of the setting press has a calotte shape which is coaxial, in particular relative to the metal blank receptacle and/or the setting punch, and protrudes in axial direction A into the cavity, for introducing a calotte into the blank, which calotte is preferably conical, frustoconical or dome-shaped.

In addition or alternatively, the bottom side of the blank receptacle of the setting press may have a circumferential wedge shape radially on the outside to form a projectile rear bevel for inserting the projectile into the neck of a cartridge case and/or for forming a so-called "boat tail".

In accordance with a preferred configuration that can be combined with the previous ones, an inventive tool arrangement also includes an ogival forming press or ogival forming station. This has a hollow-cylindrical projectile blank receptacle or ogival die, which is delimited in the axial direction by a concave, ogival-shaped bottom side, preferably a pointed punch, in particular with a blunt end, and which has a projectile foot punch or ogival die. A projectile rear punch for holding and/or centering the foot end (or the rear) of the internally contour-formed projectile blank, which is movable relative to the bottom side for forming the solid projectile up to an ogival-shaped end position. The projectile foot punch, the projectile blank receptacle and the base side define a cavity which defines a projectile negative with an ogival portion and preferably directly adjacent thereto cylinder portion.

The invention also concerns a method for producing metallic solid projectiles for practice cartridges, preferably with a rotationally symmetrical ogival cavity, in particular for use on police firing ranges. The method consists in providing a metal blank formed in particular from cut-to-length metal wire, preferably with a cylindrical outer surface. The metal blank can be provided, for example, by separating (assembling) a metal blank from a metal wire of predetermined length, predetermined mass and/or predetermined nominal diameter, in particular a predetermined caliber diameter. To provide the metal blank, it can be cut to length from a metal wire by cutting, for example by sawing or milling, or without cutting, for example by punching or cutting.

Alternatively or additionally, a setting tool such as a setting press or setting station can be used to provide the metal blank. When a metal blank is provided using a setting tool, for example, a metal blank with a predetermined mass, for example 1/10 g, 1/100 g or 1/1000 g of precisely dimensioned mass, can be provided, which is brought to a predetermined nominal diameter in a setting step following this finishing step using a setting tool, preferably a setting press, in particular as described above. The metal blank provided is provided in particular in a fully cylindrical form. If the metal blank is provided using a setting tool, an e.g. truncated conical centering recess can be made in the front of the metal blank as part of the setting step. When carrying out a setting step, the metal blank can be formed at the foot end, which in the course of the manufacturing method is transformed into a foot-side projectile part to be inserted into the neck of a practice cartridge case. When providing the metal blank, a calotte and/or an outer chamfer or boat-tail shape can be formed on the metal blank at the rear, for example, particularly in the setting step.

In accordance with the invention, the metal blank is formed in a preforming step into a projectile blank (first stage) with a sleeve-shaped section which, at the end of the preforming step, extends over more than half the size of the axial height of the blank, the sleeve-shaped

section in particular being formed with a preferably continuously tapering inner contour. The inner contour of the sleeve-shaped section of the first-stage projectile blank may preferably be conical and/or rotationally symmetrical. It is clear that the taper tapers towards the foot end of the projectile blank. Preferably, the thickness of the case wall in the axial direction of the first-stage projectile blank increases steadily. In the preforming step, the metal blank is preferably formed into a projectile blank with an essentially cylindrical outer surface of constant diameter, forming a sleeve-shaped section on the inside with a preferably conically tapering inner contour.

In the preforming step, a fully cylindrical stem portion may remain at the rear of the projectile blank extending in the axial direction over less than half, less than 40%, less than 30%, less than 20%, less than 10% or less than 5% of the maximum axial projectile blank height. For example, when the projectile blank is formed as described above, the largest axial projectile blank height extends between the upper ring end and the lower ring end of the projectile blank. Preferably, a fully cylindrical stem section of the projectile blank remains after the preform step. Alternatively, during the preforming step, the first-stage projectile blank may have been completely sleeve-shaped so that the projectile blank (first stage) was completely penetrated in the axial direction, in particular by forming an axial passage. A completely penetrated projectile blank is (not only in sections but) completely sleeve-shaped. If a calotte or the like is or has been formed at the foot or tail, it is clear that this calotte has a different inner contour than the preferably continuously tapering inner contour of the sleeve-shaped section formed in the preforming step. In the fully penetrated alternative design, the first stage projectile blank is formed without a remaining fully cylindrical stem section, or with a remaining fully cylindrical stem section of height zero. Preferably, the nominal diameter of the outside of the metal blank in the first stage projectile blank produced by the preforming step is retained unchanged during the preforming step.

In the preferred configuration of an inventive method, the (preformed) projectile blank (first stage) is formed into an (internally shaped) projectile blank (second stage) in an inner contour forming step after the preform step. This is done in such a way that an end-side or front sleeve portion of the projectile blank is formed with a radially outer sleeve wall of substantially constant wall thickness and/or cylindrical inner contour, and that a rear-side or foot-side sleeve portion of the projectile blank is formed with a shoulder projecting radially inwards from the sleeve wall, and that a shaft starting from the shoulder, in particular at its radially inner edge, is formed which extends into the rear sleeve portion of the projectile blank. The shaft in particular forms a microchannel and/or a deformation cavity, wherein the deformation cavity is formed at least in sections cylindrically and/or at least in sections conically with taper at the front side.

The inner contour forming step can preferably be carried out with a particularly tapered and/or rotationally symmetrical inner contour forming punch, such as a round punch, preferably in a projectile blank receptacle or die. The diameter of the cylindrical outer surface of the projectile blank is preferably retained during the inner contour forming step.

At the end of the inner contour forming step, a distance in the axial direction between the shoulder of the second stage projectile blank and a lowermost end of the inner contour formed projectile blank, which may also be referred to as the tail or foot, shall preferably be greater than the axial height of the fully cylindrical stem section of the projectile blank which may be present at the end of the preforming step. The opposite shoulder surfaces are preferably in contact with each other at the front end of a microchannel. The second stage projectile blank can be formed during the inner contour forming step by forming a capillary-like microchannel with a clear width of less than 10 μm or 1 μm . Between the front side sleeve section and the deformation cavity of the projectile blank at the rear, preferably an hourglass-shaped constriction is formed during the inside contour forming step. During the inner contour forming step, the shaft extending rearwardly from the shoulder can be shaped in such a way that a cavity is formed which is at least partially dissolved in the course of the inner contour forming step, in particular with the formation of a microchannel, in that the inner surface of the shaft is brought close to one another, preferably up to a sectional or flat contact.

According to a preferred further configuration of the invention, the projectile blank (second stage) is formed in the inner contour forming step in such a way that the deformation cavity forms a waist-shaped constriction at the front side. When the waist-shaped constriction is formed, a microchannel is formed in particular between the deformation cavity and the shoulder, in which the inner wall surface of the sleeve section is brought together, especially in contact.

Alternatively or additionally, according to a preferred further configuration of the invention, a distance in the axial direction between the shoulder and the foot of the projectile blank (second stage) may be greater than the axial height of the fully cylindrical stem section of the projectile blank (first stage) which may be present at the end of the preforming stage.

According to a preferred configuration of the invention, the method includes an ogival forming step. In an ogival forming step, which can take place after the preforming step and in particular after the inner contour forming step, the projectile blank, in particular the second stage projectile blank, is formed in such a way that the frontal sleeve wall forms an outer surface which is at least in sections ogival in shape. In particular, a frontal opening can be maintained, which preferably opens into an ogival cavity defined circumferentially by the sleeve

wall. Preferably, the ogival cavity can be defined on the front side by the shoulder. The ogival forming step can, for example, be effected by pressing the first or second stage projectile blank into an ogival forming tool with an ogival inner contour with the aid of a rear punch which holds the projectile blank at the rear, so that the end sleeve wall, which is defined by the preforming step and, if appropriate, the inner contour forming step, is compressed radially inwards. In the ogival forming step, an ogival cavity is preferably formed which is surrounded by the sleeve wall of the solid projectile. Preferably in the ogival forming step, the projectile blank (first or second stage) is formed into a solid projectile, in particular as described above. The ogival cavity formed in the ogival forming step is preferably formed in the axial direction completely free of edges and/or with rounded edges and/or rounded inner contour. For example, the ogival cavity can be essentially bell-shaped in the ogival forming step.

In accordance with a preferred configuration of the method in accordance with the invention, which can be combined with the execution or further configurations of the method as described above, the preforming step, the inner contour forming step and/or the ogival forming step, as well as, if applicable, the cutting to length step and/or the setting step, if applicable, to be carried out are carried out without cutting, in particular by cold forming, preferably by pressing. A non-cutting inner contour forming step can, for example, be carried out using a preferably tapered, in particular rotationally symmetrical inner contour forming punch, such as a round punch, in a projectile blank receptacle or die.

In accordance with a preferred configuration, the inventive method of making a metallic solid projectile for practice cartridges also includes one or more intermediate and/or post-treatment steps, such as coating steps. In one or more coating steps, a coating is applied to the outer and/or inner surface at least in sections, in particular completely. A coating shall preferably be applied with a coating thickness of less than 500 μm , less than 100 μm , less than 10 μm or less than 3 μm or 1 μm thickness. A coating step may, for example, include a galvanic coating of the solid projectile.

The method according to the invention for producing a metallic solid projectile for practice cartridges can be used in particular to produce a metallic solid projectile according to the invention according to the first and/or second aspect of the invention. The inventive method of making a metallic solid projectile for practice cartridges may preferably be carried out using an inventive tool arrangement for making metallic solid projectiles for practice cartridges. It is clear that a metallic solid projectile according to the invention (in particular according to the first and/or second aspect of the invention) may be manufactured according to one or more steps of the manufacturing method according to the invention. The invention also re-

lates to a projectile manufactured by a method according to the invention for the manufacture of a metallic solid projectile for practice cartridges as described above. A metallic solid projectile according to the invention may preferably be manufactured with a tool arrangement according to the invention.

Preferably, the arrangement of tools according to the invention is configured to create a solid projectile according to the first and/or second aspect of the invention. In particular, the invention tool arrangement may be configured to perform a manufacturing method according to the invention.

The invention also concerns a cartridge with a solid projectile, in particular exactly one, in accordance with the invention. Furthermore, the invention concerns a handgun, preferably a handgun, such as a pistol or a revolver, or a submachine gun, which comprises at least five practice cartridges with a metallic solid projectile in accordance with the invention. Preferably, the handgun or the solid projectile is suitable for cartridges with a caliber of maximum 20 mm, in particular maximum 12 mm. In particular, the cartridge or handgun may be configured for calibers of 9 mm Luger, .357 Mag., .40S&W, .44 Rem. Mag. or .45 ACP.

Further details, advantages and characteristics of the invention are explained by the following description of preferred executions using the enclosed drawings.

- Fig. 1a shows a plan view of a solid projectile according to the invention according to a first configuration;
- Fig. 1b shows a sectional view according to the section line I.-I. of a solid projectile according to invention according to Fig. 1a;
- Fig. 2 shows a sectional view of another solid projectile according to the invention;
- Fig. 3 shows a sectional view of another solid projectile according to the invention;
- Fig. 4 shows a sectional view of another solid projectile according to the invention;
- Fig. 5 shows a sectional view of another solid projectile according to the invention;
- Fig. 6 shows a sectional view of another solid projectile according to the invention;

- Fig. 7 shows a schematic cross-sectional view of a used solid projectile according to the invention;
- Fig. 8 shows a setting press of a tool arrangement;
- Fig. 9a shows a preform press of a tool arrangement according to the invention;
- Fig. 9b shows a preformed projectile blank;
- Fig. 9c shows another preformed projectile blank;
- Fig. 10a shows an inner contour forming press;
- Fig. 10b shows an internally contoured projectile blank; and
- Fig. 11 shows an ogival forming press.

Figure 1a shows a plan view of a solid projectile 1 and Figure 1b a sectional view according to section line I-I. The solid projectile 1 comprises a frontal ogival section 3 and a foot-side cylinder section 5. As can be seen clearly in the sectional view shown in Figure 1b, the solid projectile 1 is made of a single piece of homogeneous material. The material of the solid projectile 1 is preferably copper. The surface of projectile 1 can be provided with a thin coating. In the ogival section 3, projectile 1 has an ogival curved, rotationally symmetrical outer contour 34, which is pierced by a circular opening 11 at the front side 13 of projectile 1. At the tip or front 13 of projectile 1, the opening 11 with the opening diameter d_o is provided concentrically and preferably rotationally symmetrically to the axis of rotation A of projectile 1. Starting from the projectile tip 13, the ogival wall 31 extends like a dome with an ogival outer contour 34. Starting from the projectile tip 13, the outer contour 34 describes in axial direction A a continuously rounded widening ogival shape. Near the apex 3, projectile 1 has a radius of curvature of about 3.1 mm. Close to the cylinder section, the rounding radius of the outer contour 34 is about 23.5 mm.

The opening angle of the outer contour 34 with respect to the axis of rotation A is initially blunt (near the projectile tip 13), so that a blunt projectile tip 13 with an opening angle of 150° to 180° , preferably about 180° , is formed in particular as a result of the frontal opening 11. Starting from the blunt tip 13 of projectile 1, the opening angle of the outer contour 34 of ogival section 3 preferably increases continuously.

In Figure 1, the solid projectile 1, the opening angle relative to a tangent of the outer contour 34 at an axial distance of about 1 mm from the blunt tip 13 of projectile 1 is between 120° and 140° , especially at about 130° .

At a distance of approximately 2 mm in axial direction A from the blunt tip 13 of projectile 1, the tangential opening angle shall be between 110° and 90° , in particular approximately 100° . In the solid projectile 1 shown in Figure 1, the ogival outer contour 34 of the ogival section 3 extends in such a way that after approximately 8 mm to 11 mm, preferably between 9 mm and 10 mm, in particular at approximately 9.6 mm, the tangent oriented in axial direction A to the outer contour 34 extends substantially parallel to the axis of rotation A of projectile 1. From this point the outer contour 34 extends in the cylinder section 5 of projectile 1. In the cylinder section 5 the outer contour 34 of projectile 1 runs essentially ideally cylindrical. In cylinder section 5, the outer contour 34 of projectile 1 is arranged essentially parallel to the axis of rotation A of projectile 1. The cylinder section 5 defines the largest diameter D_z , which can be referred to as the projectile diameter or caliber diameter. The outer diameter D_z of a projectile for a 9 mm Luger caliber training cartridge can measure 9.02 mm. The cylinder section 5 of projectile 1 is intended to be inserted at least partially in axial direction A into the (unrepresented) neck of a (unrepresented) cartridge case.

The cylinder section extends in the axial direction of projectile 1 over 5 mm to 10 mm, preferably between 6 mm and 9 mm, in particular between 7 mm and 8 mm, preferably between 7.2 mm and 7.8 mm, preferably about 7.5 mm.

At the end 71 of projectile 1 remote from the tip or end 13, the projectile 1 has a flat foot section or foot extending transversely, in particular at right angles to the axis of rotation A. A calotte 73 can be inserted in the foot 71 of projectile 1, which is preferably coaxial and concentric to the rotation thing A. The calotte 73 can be inserted in the foot 71 of projectile 1. The calotte 73 is preferably conical and tapers towards the front. A dome 73 tapered at the front can alternatively be dome-shaped or frustoconical. The dome 73 preferably has a depth of 1.5 mm in axial direction A. The dome 73 has a depth of 1.5 mm in axial direction A.

The rear side edge 75 between the flat tail 71 and the cylindrical outer contour 34 in the area of the cylinder section 5 of projectile 1 is preferably realized by a chamfer-like cone section 75. For example, the cone section 75 can extend 1 mm in axial direction A and preferably have an opening angle of about 60° . A cone section 75 can also be formed as a longer and/or more pointed so-called "boat tail" section.

Projectile 1 has a bell-shaped, rotationally symmetrical ogival cavity 33, which is completely surrounded in radial direction R by the ogival wall 31. On the front side, the ogival cavity 33 opens into opening 11 of projectile 1. The narrowest clear width of opening 11 defines an opening diameter d_o which is between 1 mm and 5 mm, preferably about 3 mm. The inner wall 15 of opening 11 surrounds opening 11 in a ring. Preferably, the inner wall 15 forms a ring edge that is free of radial and/or axial steps in the circumferential direction. In particular, the inner wall 15 of the opening 11 can merge into the outer contour 34 of the ogive section 3 without edges and/or completely rounded. As can be seen in the plan view of projectile 1 shown in Figure 1a, the inner wall 15 of opening 11 is uninterrupted in the circumferential direction. The inner wall 15 is preferably free of axially extending notches and/or steps. The tip 13 of projectile 1 is preferably formed by an essentially smooth annular transition from the inner wall 15 to the outer contour 34.

In axial direction A, opening 11 opens into ogival cavity 33. The transition from opening 11 to ogival cavity 33 may preferably be completely rounded. In the depicted configuration of a projectile as shown in Figure 1b, a blunt annular edge with an obtuse opening angle greater than 135° is formed between the ogival cavity 33 and opening 11.

The inner contour 32 of the ogival wall 31, which defines the shape of the ogival cavity 33 circumferentially, is continuously rounded in axial direction A. The inner contour 32 of the ogival wall 31, which defines the shape of the ogival cavity 33 circumferentially, is continuously rounded in axial direction A. In the circumferential direction, the inner contour 32, which surrounds the ogival cavity 33, has no steps, jumps, edges or projections. The ogival wall 31 is circumferentially preferably completely free of axial grooves, projections, notches or the like.

The bottom 35 of the ogival cavity 33 is formed by shoulders 35 projecting radially inwards from the ogival wall 31. The curves of the inner contour 32 preferably merge into the bottom 35 without steps and/or edges, preferably completely rounded. The curves of the inner contour 32 along the ogival wall 31 are preferably formed with radii of curvature which are at least 0.5 mm and up to 5 mm in size. Preferably the inner contour 32 of the ogival wall 31 has radii of curvature which are at least 0.5, at least 0.75 or at least 1 mm in size.

The wall thickness of the ogival wall 31 in radial direction R is preferably between 0.3 mm and 3 mm. In particular, the wall thickness of the ogival wall 31 can be between 0.5 mm and 2 mm. The smallest wall thickness in the radial direction of the ogival wall 31 is preferably more than 0.5 mm, preferably between 1.0 mm and 1.5 mm. At right angles to the wall, the wall thickness can be greater than 1 mm.

A solid projectile 1 according to the invention can have a cavity which comprises the ogival cavity 33 and the opening 11, which in axial direction A extends completely over at least the ogival section 3.

The inwardly projecting shoulder 35 which defines the bottom of the ogive cavity 33 and which preferably completely delimits the ogive cavity 33, in particular in axial direction A on the foot side, may have an opening or mouth 37 in the centre. The height of the ogival section 3 in axial direction A has the reference sign l_0 . The muzzle 37 is preferably concentric and/or coaxial to the axial direction A. The muzzle 37 has the reference symbol l_0 . Starting from the muzzle 37, a shaft 55 extends in axial direction A at the foot of the ogive cavity 33 into the cylinder section 5 of projectile 1. The shaft 55 begins at the foot of the ogive cavity 33. The shaft 55 can open with a throat-like opening or muzzle 37 into the ogive cavity 33. Shaft 55 shown in Figure 1b has a microchannel 57 and a deformation cavity 53. In the area of microchannel 57, the diagonally opposite inner chamber edge sections meet. In the area of microchannel 57, a capillary section can be formed in which a channel extends in axial direction A from the ogival cavity 33 at the rear of the projectile, which has a clear width of less than 10 μm or less than 1 μm . Microchannel 57 has a clear width which is preferably considerably smaller than the opening diameter d_0 of opening 11 at the tip 13 of projectile 1. Preferably, the clear width of microchannel 57 is smaller than 2 mm, in particular smaller than 1 mm.

For example, the shaft mouth 37 can form a kind of funnel-shaped transition area between shaft 55 and the ogival cavity 33. Preferably, the bottom 35 of the ogival cavity 33, in particular without steps and/or edges, is rounded to the mouth 37. The mouth 37 is preferably rounded and merges into the other sections of shaft 55, e.g. the microchannel 57 and/or the deformation cavity 53.

At the foot of microchannel 57, shaft 55 has a deformation cavity 53 which expands in a conical shape in the rear direction. The deformation cavity 53 has an essentially flat end at the rear in axial direction A, which preferably extends transversely, in particular perpendicularly, to axial direction A in radial direction R. In the direction of the tip or front side, the deformation cavity 53 is wedge-shaped, in particular conical, and tapers.

Shaft 55 is rotationally symmetrical at least in sections or in the axial direction with respect to the projectile axis A. In radial direction R, shaft 55 is surrounded by a deformation sleeve wall 51 of projectile 1. The wall thickness of the deformation sleeve wall 51 is greater than the wall thickness of the ogival wall 31. In particular, the smallest wall thickness of the deformation sleeve wall 51 is greater than the largest radial wall thickness of the ogival wall 31. The wall thickness of the deformation sleeve wall 51 can be between half and $\frac{1}{4}$ of the cylinder

diameter (or caliber diameter) D_z . Preferably the wall thickness of the deformation sleeve wall 51 is greater than $2/3$, greater than $3/4$ or even greater than 90% of half the (caliber) cylinder diameter D_z .

The wall thickness of the ogival wall in the axial area of the ogival cavity 33 is preferably smaller in the middle than $1/4$ of the (caliber) cylinder diameter D_z .

The axial height l_H of the deformation sleeve wall 51 surrounding the shaft 55 extends in the axial direction between 5 and 10 mm, preferably between 6 and 9 mm, in particular between 7 and 8 mm, preferably starting from the shoulder bottom 35 of the ogive cavity 33. The axial height of the deformation cavity 53 is greater than the length of the microchannel section 57. In particular, the axial height of the deformation cavity 53 can be at least twice the axial height of the microchannel 57.

The cylinder section 5 extends from the foot or tail 71 of the projectile to the ogival section 3 over 3 mm to 10 mm (height l_z), preferably between 4 mm and 8 mm, in particular over about 6 mm.

The calotte preferably has an outside diameter of 4 to 6 mm at the rear, in particular 5 mm. Instead of the truncated cone section 75 shown, the edge between the tail 71 and the cylindrical outer contour 34 in the region of the cylindrical section 5 may be completely rounded, in particular with a radius of curvature between 0.3 and 1.5 mm, preferably between 0.4 and 1 mm. Since a deformation cavity 53 widening at the rear is provided in the cylinder section 5 and, if necessary, a calotte 73, it can be achieved that the center of gravity of projectile 1 is shifted in axial direction A in the direction of the front side of projectile 1. The deformation cavity 53 and, if necessary, the calotte 73 serve or serve as mass compensation relative to the ogival cavity 33 provided on the front side. By adjusting the axial balance of the projectile's center of gravity, its flight characteristics can be optimized. For example, a projectile according to the invention can be designed for training cartridges to achieve similar ballistic properties, such as weight, if necessary center of gravity, and/or shooting sensation, according to standard training cartridges or training cartridges, for example the 9x19 ACTION 4 ammunition.

The solid projectile 1 depicted in Figure 1b and Figure 1a has a solid, fully cylindrical projectile stem 7 or stem section, respectively, in which the projectile is formed in axial direction A in the form of a solid, in particular cavity-free solid cylinder. The stem 7, in particular in the middle, coaxial to the projectile axis A, has no cavity, in particular no cavity which extends axially in the form of a thin capillary channel with the formation of inner edges. Preferably,

the fully cylindrical stem 7 has an ideal cylindrical outside. In an alternative embodiment of a projectile with a boat tail, the stem 7 can be truncated conically on the outside at least in sections. In a transverse section, especially perpendicular to the axis of rotation A of projectile 1, the stem cross-section 7 is circular. The height of the stem 7 between the stern 71 or a calotte 73 formed in the stem 71 and the stem end of the deformation cavity 53 (stem height l_s) is less than 5 mm, preferably less than 3 mm, in particular less than 2 mm or less than 1 mm. According to an alternative configuration of a projectile according to the invention, the projectile may be fully penetrated in the axial direction without the use of a stem. Such projectiles are described in more detail below.

Figures 2 to 6 show different alternative configurations of solid projectiles for practice cartridges according to the invention. The solid projectiles depicted in Figures 2 to 6 largely correspond to the solid projectile depicted in Figure 1b. The solid projectiles of Figures 2 to 6 differ from the solid projectile 1 as shown in Figure 1b in the type, shape and size of the shaft extending from the ogive cavity into the cylindrical section of the projectile. The solid projectiles of Figures 1b to 6 have practically the same outer contour, in particular the same dimensions in axial direction A and/or radial direction R. For easier legibility of the figure description, the same or similar reference signs are used below for Figures 2 to 6 for similar or identical parts of the solid projectile according to the invention.

Figure 2 shows a solid projectile 1.2 which differs substantially from the solid projectile 1 as shown in Figure 1b in that the inner walls of shaft 55.2 are joined in axial direction A over a greater length than the axial height of the deformation cavity 53.2.

The axial height of the microchannel section 57.2 is greater than the axial height of the deformation cavity 53.2, in particular at least twice as large. At the solid projectile 1.2 the shaft 55.2 has a throat-like mouth 37.2, which widens funnel-shaped from the micro channel 57.2 to the bottom 35.2 of the ogival cavity 33. Between the foot end of the conically tapering deformation cavity 53.2 at the front and the calotte 73 at the foot 71 of projectile 1.2, projectile 1.2 has a stem 7.2. The axial height of the stem 7.2 is greater than the axial height of the deformation cavity 53.2. A deformation projectile 1.2 as shown in Figure 2 may be produced, for example, by producing a deformation projectile 1 as shown in Figure 1b according to a target specification, but more metal material is provided for production. The excess material compared to the shape of the solid projectile 1 is tolerated in the case of the solid projectile 1.2 by the fact that the opposite inner side sections of the shaft 55.2 are pushed closer together in the radial direction R. The deformation projectile 1 is a solid projectile 1.2.

Figure 3 shows a solid projectile 1.3 with a tubular shaft 55.3. The shaft 55.3 of the solid projectile 1.3 forms a deformation tube 58.3 extending in axial direction A coaxial to the axis of rotation A of the solid projectile 1.3 with a substantially constant clear width. The deformation tube 58.3 may have a constriction in the axial direction. Shaft 55.3 has a deformation cavity 53.3, which extends essentially over the entire length of shaft 55.3 to its mouth 37.3. The deformation tube 58.3 or the microchannel of the solid projectile 1.3 can be regarded as a cylindrical deformation cavity 53.3 in sections, which merges into the ogive cavity 33 at the mouth 37.3. The deformation sleeve 51.3 of the solid projectile 1.3 therefore has a cylindrical outer side and a nearly cylindrical, waisted inner side, which defines the deformation tube 58.3. The largest clear width of the deformation tube 58.3 is smaller than the clear width of the front opening 11, in particular narrower than half, preferably narrower than $\frac{1}{4}$ of the clear width. The wall thickness in radial direction R of the deformation sleeve 51.3 is greater than the mean wall thickness of the ogival sleeve 31.3.

Figure 4 shows a solid projectile 1.4 for an exercise cartridge, in which the shaft 55.4 is shaped in axial direction A to form a stem 7.4 of similar length to the shaft 55.3 of the solid projectile 1.3 according to Figure 3. The shaft 55.4 is narrowed along its entire axial length to a microchannel 57.4, which preferably extends capillary-like from the mouth 37.4 into the cylinder section 5 of the solid projectile 1.4. The clear width of the microchannel 57.4 is preferably smaller than $\frac{1}{10}$, in particular smaller than $\frac{1}{100}$ of the clear width of the front opening 11 of the solid projectile 1.4. The shoulders 35.4 of the solid projectile 1.4 are guided together in such a way that the mouth 37.4 of the shaft 55.4 is narrowed point-like. The solid projectile 1.4 is formed with practically complete dissolution of the deformation cavity. This can be regarded as a further narrowing of shaft 55.4 in comparison with shaft 55.2 of solid projectile 1.2 or shaft 55 of solid projectile 1. Compared to the solid projectiles 1, 1.2 and 1.3, the solid projectile 1.4 has an increased solid material volume, since the cylinder section 5 of the solid projectile 1.4, despite the formation of a deformation sleeve section 51.4, has practically the same mass as the solid projectile known from the state of the art (which, however, does not have a deformation sleeve 51.4).

Compared with the solid projectiles 1, 1.2, 1.3 and 1.4 shown in Figures 1b to 4, the solid projectiles 1.5 and 1.6 shown in Figures 5 and 6 differ in that the shaft 55.5 and 55.6 penetrates the cylinder section 5 of projectile 1.5 and 1.6 respectively completely. The solid projectiles 1.5 and 1.6 do not have a cylindrical stem section. In other words, a fully cylindrical stem section has zero height in the solid projectiles 1.5 and 1.6 shown in Figures 5 and 6, respectively.

The solid projectile 1.5, shown in Figure 5, has a tubular shaft 55.5 with a clear width which is almost constant in the axial direction and which extends completely through the cylinder

section 5. As a result of the continuous deformation tube 58.5 of the solid projectile 1.5, the cylinder section 5 is completely realized as deformation sleeve 51.5. The deformation tube 58.5 can be regarded as a deformation cavity 53.5 or shaft 55.5, which essentially extends cylindrically from the mouth 37.5 to the dome 73 of the solid projectile 1.5. It is clear that a shaft 55.5 penetrating completely into the projectile can also extend to the rear 71 of projectile 1.5 if no calotte 73 is provided at the rear of projectile 1.5 (not shown). The same applies to shaft 55.6 as shown in Figure 6. The projectile 1.5 may be described as a completely sleeve-shaped solid projectile. It has a continuous axial channel consisting of the front opening 11, the ogival cavity 33 and the deformation tube 58.5. The smallest clear width of this axial channel corresponds to the smallest clear width of the deformation tube 58.5. The smallest clear width of the deformation tube 58.5 or the microchannel of the solid projectile 1.5 defines a diameter smaller than that of the front opening. The smallest clear width of the deformation tube 58.5 is preferably smaller than 2 mm, in particular smaller than 1 mm, in particular preferably smaller than 0.5 mm. The largest clear width of the deformation tube 58.5 is preferably realized at its transition to the ogival cavity (the mouth 37.5) and/or the opening on the calotte or rear side and preferably measures less than 2 mm, in particular less than 1 mm. Preferably, the radial difference between the smallest clear width and the largest clear width of the 58.5 deformation tube penetrating the cylinder section 5 is less than 0.5 mm, preferably less than 200 μm , in particular less than 100 μm .

With respect to the solid projectile 1.6 shown in Figure 6, shaft 55.6, which completely penetrates cylinder section 5 in axial direction A, is tapered section by section to a microchannel 57.6. The microchannel 57.6 can preferably be capillary-like with a clear width of less than 10 μm , preferably less than 1 μm . Preferably, the capillary-like narrowed section of the microchannel 57.6 extends over at least half, preferably at least $2/3$, in particular at least $3/4$, of the axial length of the shaft 55.6. The shaft 55.6 can be widened on the front side, at the mouth 37.6, and/or on the rear side, at the mouth to the calotte 37 or the projectile tail 71, to form a tube-like or tube-like microchannel 57.6. with a larger internal width. Similar to the solid projectile 1.4 shown in Figure 4, the solid projectile 1.6 has practically the same mass as the solid projectile for practice cartridges known from the state of the art (which, however, has no deformation case 51.6 or the like).

Figure 7 shows a schematic cross-sectional view of a solid projectile 1', in accordance with the invention, after its impact on a target or a projectile-proof vest, like a ballistic vest of protection class I. The solid projectile 1', deformed by the impact, is clearly compressed both in the area of the ogive section 3' as well as in the area of the cylinder section 5'. The shaft 55' extending into the cylinder section 5' of the solid projectile 1' is widened by the impact of the projectile 1' on the target or the like under plastic deformation. In contrast to the known solid

projectiles, the plastic deformation takes place in the form of a buckling and over a significantly increased axial length in axial direction A of the solid projectile 1', so that the kinetic energy of the invented solid projectile is converted into plastic deformation energy at a relatively higher degree of efficiency when it hits a resistance than with conventional projectiles. The impact with a resistor, especially a soft target such as SK I, results in only a slight transverse deformation of the projectile. Preferably, the ogival case wall 31 folds radially outwards on impact. During folding, a radially outermost ring bend 31' can form. Preferably, the projectile will not mushroom in the radial direction outwards as the projectile tip moves, especially beyond the radial caliber diameter. On impact with the resistor, the 55' shaft expands in the radial direction R both in the area of the possibly existing 57' microchannel section and in the area of a possibly existing 53' deformation cavity. With respect to solid projectile 1' according to the invention, both the ogival sleeve wall 31' and the deformation sleeve wall 51' are deformed.

The solid projectiles described above according to the preferred embodiments of Figures 1 to 7 concern solid projectiles for practice cartridges according to the 9 mm Luger caliber, which is particularly common in Germany and is also known as 9 mm Para or 9 x 19 (mm). It is clear to the person skilled in the art that he can also produce a corresponding projectile geometry for a solid projectile according to the invention for other calibers. The person skilled in the art knows how to scale the projectile length l_D and/or the (caliber) projectile diameter D_Z for this purpose in order to arrive at a corresponding solid projectile of other calibers according to the invention, for example the caliber .357 Mag., the caliber .40 S&W, the caliber .44 Rem. Mag. or the .45 ACP caliber.

In the following, with the aid of Figures 8 to 11, a tool arrangement in accordance with the invention for carrying out a manufacturing method in accordance with the invention for the manufacture of metallic solid projectiles for practice cartridges in accordance with the invention is described.

Figure 8 shows a setting press 100, which can be part of a tool arrangement according to the invention. The setting press 100 has as essential components a metal blank receptacle 105x, a rear punch with a bottom side 107x and a setting punch 115x. The setting punch 115x preferably has a cylindrical outer diameter which essentially corresponds to the inner diameter of the metal blank receptacle 105x. The inner diameter of the 105x metal blanks receptacle is preferably dimensioned according to the desired caliber diameter of the projectile to be produced.

Figure 8 shows a setting press 100 in a position in which the setting punch 115 is arranged in its widest position in operation with respect to the bottom side 107x or the metal blank receptacle 105x (setting end position). A cavity is formed between the front side 113x of the setting punch 115x, the cylindrical inner side of the metal blank receptacle 105x and the bottom side 107x, in which a metal blank 1x is located. The metal blank 1x shown in Figure 8 has a centering punching, which is inserted by a centering projection of the setting press 100 at the front 13x of the metal blank 1x. At the rear side 71x of the metal blank 1x opposite its front side 13x the fully cylindrical metal blank 1x has a dome like indentation in the middle and concentrically by a correspondingly formed, cone-shaped calotte form nose 173x at the bottom side 107x, thus the front side of the rear punch. Radially on the outside, the metal blank 1x has a phase-like truncated cone section 75x on its rear side 71x, which is arranged in the edge area between the rear 71x and the cylindrical circumferential side 5x of the metal blank 1x. The phase side truncated cone section 75x is defined by corresponding taper in the transition area between the rear punch and the cylindrical inner wall of the setting die 105x.

For the setting forming of the metal blank 1x in the setting press 100, an essentially cylindrical metal blank (not shown) is first provided, which was cut to length, for example, from a copper wire. Cutting to length can be done by cutting, for example by sawing or milling, or without cutting, for example by punching or cutting. The cut-to-length metal blank is then placed in the 105x metal blank receptacle. The setting punch 115x is then moved relative to the bottom side 107x until the cavity between the setting punch 115x, the die or metal blank receptacle 105x and the bottom side 107x is reduced to the setting end position shown in Figure 8. The bottom side 107x of the press is formed by the top face of a rear punch. In the setting press, the metal blank is formed into the 1x metal blank shown in Figure 8 by press forming, i.e. cold forming. The setting of the metal blank which is used for forming into a projectile, especially in a setting press 100, is an optional step of the manufacturing method according to the invention. A metal blank can also be supplied to a preforming press or for a preforming step immediately after cutting to length from a metal wire, such as a copper wire, without a previous setting step.

Figure 9a shows a preform press 101 of a tool arrangement according to the invention. Figures 9b and 9c show projectile blanks 1a, 1a' (first stage) manufactured in a preform press.

The preform press 101 has as essential components a hollow-cylindrical projectile blank receptacle 105a as well as a bottom side 107a, which limits the projectile blank receptacle 105a in axial direction A, and a preform punch 111 with a preform section 112 which tapers in axial direction to a frustoconical front surface 113. The preform die 111 has a cylindrical guide section 115, which is complementary in shape to the cylindrical inner diameter of the projectile

blank receptacle 105a, in order to guide the preform die during the preform pressing method. The bottom surface 107a is formed as part of a rear punch. The ejection punch or rear punch defines, preferably together with the lower end portion of the preform die 105a, the geometry of the rear 71 (with calotte 73 if necessary) of the projectile blank 1a, 1a' (first stage).

Figure 9a shows the preform press 101 with the preform punch 111 in the operational end position (preform end position), in which a preform cavity for defining the inner and/or outer contour of the projectile blank 1a (first stage) is defined between the preform punch, the projectile blank receptacle 105a and the base side 107a. To form a rotationally symmetrical ogival cavity, the preform section 112 of the preform punch 111 is formed in the presence of a truncated cone shape and rotationally symmetrical. In the preform end position shown in Figure 9a, an axial distance h_s is formed between the bottom 107a and the front surface 113 of the preform punch 111. In the version shown in Figure 9a, the base 107a has a dome-shaped nose which, starting from a flat, ring-shaped base, extends axially into the cavity. The preform axial distance h_s or the preform stem height h_s is measured in this configuration of the preform press between the tip of the calotte form nose 171a of the rear punch and the front surface 113 of the preform punch 111. In another configuration (not shown) of a preform press 101, in which the bottom 107a is configured without calotte form nose 173a, the preform stem height h_s would extend between the flat foot form section 171a of the rear punch and the front surface 113 of the preform punch 111.

The preform punch 111 has a tapered preform section 112, which leads into a front surface 113. The front surface 113 can be very narrow. The preform section 112 according to Figure 9a has the shape of a truncated cone that is rotationally symmetrical to axis A. The preform section 112 can be very narrow. Other rotationally symmetrical tapering shapes, such as a parabolic shape or a sectionally rounded shape, are conceivable. The base of the preform section 112 has the same outer diameter as the guide section 115 of the preform punch 111. In the preform end position shown in Figure 9a, between the base of the preform section 112 and the rear surface 171a of the bottom side 107a, or the largest height of the cavity h_{Ra} , is formed. The largest cavity height h_{Ra} in the preform press 101 extends between the rear surface 171a and the point furthest away from the foot surface 171a, at which the preform section 112 of the preform punch 111 preferably meets the inside of the hollow-cylindrical projectile blank receptacle 105a. In accordance with the invention, in the preform end position a stem height corresponding to the axial distance h_s is less than 45%, preferably less than 40%, in particular less than 25%, more preferably less than 10%, of the cavity height h_{Ra} . The length of the preform section 112 in axial direction A starting from the front surface 113 of the preform punch 111 is between 5 mm and 25 mm, preferably between 8 mm and 17 mm, in particular

between 10 mm and 15 mm, in particular preferably between 13.5 mm and 14 mm. The diameter of the front surfaces is preferably between 1 mm and 3 mm, in particular around 2 mm.

The tool arrangement for the setting press 100 and the preform press 101 according to the invention can use the same projectile blank receptacle 105a or metal blank receptacle 105x (same die) and/or the same bottom side 107a or 107x (same rear punch). In the case of a tool arrangement in accordance with the invention, the blank receptacle 105a or 105b (the die) and/or the bottom surface 107a or 107b (the rear punch) of the preforming press 101 and the inner contour forming press 103 may be the same. The setting press 100, the preforming press 101, the inner contour forming press 103 and/or the ogival forming press 200 can be partially or completely different from each other by an individual setting station, preforming station, inner contour forming station and/or ogival forming station.

The metal blank located in the preform press 101 by pressing punch 111 in the projectile blank receptacle 105a produces the first stage 1a projectile blank, as shown in Figure 9b. A stem height l_s remains between the truncated end 113a of the angular truncated inner contour 32 and the rear end 71a or the dome recess 73 formed therein. The stem height l_s extending in axial direction A essentially corresponds to the preform axial distance h_s according to Figure 9a, whereby metal material settling phenomena of the projectile blank 1a must be taken into account. In the axial area of the stem height l_s , the projectile blank 1a is formed with a fully cylindrical stem section 7a. In the fully cylindrical stem section 7a, the projectile blank 1a has a massive fully circular cross-section transversely to the axial direction A. The cross-section of the projectile blank 1a is the same as in the fully cylindrical stem section 7a. The stem section 7a of projectile blank 1a is formed on the foot side or rear side (away from the front 13a) of projectile blank 1a. The outer contour 34a of the projectile blank 1a is essentially ideal cylindrical and preferably has an outer diameter corresponding to the projectile cylinder diameter D_z . Preferably the projectile diameter D_z is produced in the metal or projectile blank before it is prepared in the forming press 101, and the outer diameter of the projectile remains constant at least in sections in the preforming press 101 (and possibly the inner contour forming press 103 and/or the ogival forming press 200). In particular in cylinder section 5a (or 5, 5b) of the projectile blank 1a (1, 1b), the projectile outer diameter remains constant until the end of the manufacturing method after the metal or projectile blank has been provided in the preform press.

The wall thickness of the sleeve section 3a of the projectile blank 1a increases continuously from the front 13a of the projectile blank 1a to its rear 71a, preferably continuously, especially continuously. In the front case section 3a, the (mean) wall thickness of the case wall 31a in radial direction R is smaller than the (mean) wall thickness of the case wall 31a in cylinder

section 5a. The frustoconical recess 55a in the projectile blank 1a has an inner contour 32a which corresponds essentially to the outer contour of the preform punch 111 (whose preform section 112 and front surface 113). When using a die 111 (not shown) of a shape other than a truncated cone shape, the cavity recess 55a of the projectile blank 1a will have a different inner contour complementary in shape to the respective tapered die.

Figure 9c shows an alternative embodiment of a projectile blank 1a' (first step), where different inner contour blunt ends 113a, 113a', 113a'' are shown. The line depicted blunt end 113a of the 55a'' inner contour of the projectile blank corresponds to the depiction according to Figure 9b. The dashed die ends 113a' and 113a'' show that in axial direction A at the rear die ends of the puncture cavity 55a' have a greater axial length (die end 113a') or a shorter axial length (die end 113a'') when using a forming punch which is essentially shaped as the forming punch shown in Figure 9a.

According to the dotted line 113a', the projectile blank 1a' is completely penetrated in axial direction A, so that the projectile blank 1a' is completely sleeve-shaped. The 55a' puncture opening merges with the 73a' calotte nose. It is clear that a suitably adapted preform press with a truncated cone-shaped calotte nose must be used to form such a form. The inner contour 32a' of the case wall 31a' of the projectile blank 1a' shown in Figure 9c preferably increases continuously, especially continuously, up to the point (113a') where the shaft opening 55a' of the projectile blank 1a' merges into the spherical recess 73a'. The fully penetrated projectile blank 1a' shown in Figure 9c does not have a fully cylindrical projectile blank stem. The projectile blank 1a is formed free of a projectile stem or with a projectile stem of height zero. Even with a completely penetrated projectile blank 1a, other than frustoconical preform punches can be used.

Figure 9c also shows in dashed form another possibility for forming a projectile blank with an enlarged stem with a stem height l_s compared to the projectile blank 1a depicted in Figures 9a and 9b.

Figure 10a shows an inner contour forming press 103 and Figure 10b shows a projectile blank 1b (second stage) produced with the inner contour forming press 103 shown in Figure 10a. Like the setting press 100 described above and the preform press 103 described above as well as the ogival forming press described below, the inner contour forming press shown in Figure 10a is formed with essentially rotationally symmetrical tools for forming rotationally symmetrical solid projectiles for practice cartridges. The main components of the inner contour forming press 103 are the inner contour forming punch 121, the bottom side 107b axially ar-

ranged opposite the inner contour forming punch 121 and the hollow cylindrical projectile blank receptacle 105b.

In the final position of the inner contour form, which is shown in Figure 10a, the inner contour form punch 121 delimits a cavity on the front side and the bottom side 107b or the front side 107b of the rear punch on the foot side for the projectile blank 1b. The cavity for the projectile blank 1b is externally limited in radial direction R by the ideal hollow cylindrical matrix 105b. To achieve the inner contour end position shown in Figure 10a, the inner contour forming punch 121 is pressed into the projectile blank 1a previously preformed in the preform press 103 until the projectile blank 1b second stage is formed, as shown in Figures 10a and 10b, for example.

The inner contour forming punch shown in Figure 10a has an inner contour forming portion 122 which is formed in sections in the axial direction A as a cylindrical sleeve forming portion 133. The cylindrical sleeve shape section 133 of the inner contour forming punch 121 and the inner side of the inner contour outer die 105b opposite the sleeve shape section 133 in the radial direction R define the cylindrical wall shape and the wall thickness of the end sleeve wall 31b. It is clear that the sleeve mold section 133 can be formed with a slight demolding slope, preferably less than 1° .

The front surface 123 of the inner contour forming punch 121 can be formed as a blunt cone tip with an opening angle between 130° and 180° , preferably about 160° , and rounded front rim edges 125. The blunt cone tip 123 of the inner contour forming punch 121 forms the inner contour 32b of the case section 3b of the projectile blank 1b (second stage), which, starting from the case wall 31b, extends in a shoulder-like manner in the radial direction R inwards in order to delimit the base 35b of the projectile blank main cavity 33b in the axial direction on the foot side. The rounding radius of the front surfaces 123 can be 1 mm to 3 mm, preferably 2 mm. The cylindrical sleeve forming section 133 may also begin about 1 mm, preferably from about 2 mm, in particular from about 2.5 mm, starting from the tip of the inner contour forming punch and extend to about 11 mm, preferably to about 10 mm, in particular to about 9 mm, starting from the tip of the inner contour forming punch 121.

The inner contour forming punch 121 has a guide section 127 which extends in the axial direction immediately adjacent to the forming section 122 far from the front end 123 and which is preferably formed substantially complementary to the hollow cylindrical inner side of the projectile blank receptacle 105b. The guide section 127 of the inner contour forming punch 121 can be used to safely guide the forming punch in the inner contour forming die 105b, in particular during the relative movement of the punch 121 relative to the bottom side 107b.

A preferably frustoconical transition section 128 extends in the axial direction A and in the radial direction R between the inner contour shaping section 122 or its sleeve shaping section 133 and the guide section 127 of the inner contour shaping punch 121. It is clear that the transition section 128 merges in the axial direction directly into the guide section 127 and the inner contour shaping section 122.

From the front end of the inner contour punch guide portion 127 formed by the outer annular edge of the transition portion 128 opposite the rear surface 171b, the bottom side 107 of the rear punch, the maximum axial height of the cavity (h_{Rb}) extends in the inner contour form end position.

In the inner contour form end position according to Figure 10a, there is an axial distance h_r , which may be referred to as the inner contour residual distance, between the front surface 123 of the inner contour form punch 121 and the front end of the bottom side 107b in axial direction A. As indicated in Figure 10a, the residual distance h_r is greater than the preform axial distance h_s . Preferably, the inner contour residual distance h_r is at least 1.2 times, at least 1.5 times or at least 2 times as large as the preform axial distance h_s . In the case of a narrow stem height h_s , the residual inner contour-to-contour distance h_r can be more than 10 times, more than 100 times or even more than 1000 times greater than the preform axial distance h_s .

The axial size of the inner contour molding section 122 is, as shown in Figures 10a and 10b, smaller than the axial length of the preform section 112, preferably the axial length of the preform section 112 can be at least 1.2 times, at least 1.5 times, or at least 2 times the axial length of the inner contour molding section 122. The inner contour Holding section 122 is preferably not smaller than 10%, 20%, 30% or 50% of the axial length of the preform section 112 in axial direction A.

In the inner contour forming portion, the result of which is to be seen in the form of the projectile blank (second stage) 1b in Figures 10a and 10b, the projectile blank 1b is formed so as to form in the axial direction A a sleeve-shaped front portion 3b and a rear cylinder portion 5b. The frontal cavity 33b in the projectile blank 1b is formed substantially complementary to the shape of the inner contour forming section 122 of the inner contour forming press 103.

At the bottom 35b of the internally shaped cavity 33b there is an axial central mouth 37b, which merges into shaft 55b. In the cylinder section 5b of the projectile blank 1b (second stage) a deformation sleeve 51b, which surrounds the shaft 55b radially, is formed. In the case of projectile blank 1b according to Figure 10b, the 55b shaft extends like a microchannel up to

a remaining stem height h_s , below the 55b channel a fully cylindrical projectile blank stem 7b is connected. The projectile blank 1b has a calotte recess 73b at the foot end 71b, which defines the lower end of the projectile blank stem 7b and the stem height.

The outer contour 34b of the projectile blank 1b second stage is essentially fully cylindrical and has both in the cylinder section 5b and in the front thin-walled section 3b essentially the same outer diameter which preferably corresponds to the projectile (caliber) diameter D_z . The projectile blank of the second stage (1b) essentially has the finished shaft (55b) shape, which may differ depending on the projectile, as already described in Figures 1 to 6. As described in Figure 9c with regard to an alternative projectile blank geometry (1a'), a second stage projectile blank (not shown) can, of course, be realized without a stem. The formation of the stem 7b of the second stage projectile blank is conditioned by the preforming step in the preforming press 101. If the preforming punch completely penetrates the metal or projectile blank (1a') of the first stage, the projectile blank formed from this preformed projectile blank has no stem either.

When the inner contour forming punch 121 is pressed into the preformed projectile blank held in the projectile blank receptacle 105b and from the bottom side 107b formed by a rear punch, the inner contour 32a of the projectile blank is formed in accordance with the inner contour forming section 122. When the inner contour forming punch 121 is pressed into the projectile blank, a front projectile blank section 3b is formed thin-walled, preferably with constant wall thickness, in particular at least in sections in the form of a cylindrical sleeve. The metal material of the solid projectile or projectile blank displaced by the inner contour forming punch 121 during this inner contour forming operation is displaced during the inner contour forming step in axial direction A towards the foot or rear (rear) cylinder section 5b of the projectile blank (second stage) 1b.

The conical shaft 55a formed by the preform punch 111 up to the blunt end 113 at the bottom of the inner contour 32a is formed by the inner contour punch 121 during the inner contour forming step. The conical channel 55a is formed by partial expansion into a wide cylindrical cavity 33b near the face 13b of the internally contour-formed projectile blank 1b. Towards the base 71b of the projectile blank 1b, the metal material of the projectile blank 1b is compressed in axial direction A and in radial direction R during the forming of the cone channel 55a by the inner contour forming punch 121, so that in the axial direction A the bottom shoulders 35b delimiting the cavity are formed with the central muzzle opening 37b and the shaft 55 extending in the axial direction A from the muzzle opening 37b into the cylinder section 5b of the projectile blank 1b.

During manufacture, the deformation sleeve 51b surrounding shaft 55b provides a manufacturing tolerance, the inner cavities (not shown in Figure 10b) of the deformation cavity initially formed by the conical shaft 55a and subsequently being able to accommodate material displaced during the inner contour forming step. In this way, a precisely fitting outer contour 34b of the projectile blank 1b can be guaranteed without reworking, for example by calibration or milling.

Figure 11 shows the ogival form press 200. As a main component, the ogival form press 200 comprises a rear punch 207 and a projectile receptacle 205 with a projectile tip forming punch 213 for inserting the preformed and/or inner contour formed projectile blank. This is held or at least centered by the rear punch 207 and inserted into a stationary part of the ogival form press 200 consisting essentially of the projectile receiving 205 and the projectile tip punch 213. The projectile tip punch 213 together with the projectile receptacle 205 defines the curved outer contour 203 for the ogive. The ogive matrix or projectile receptacle 205 is hollow cylindrical with an ogive-shaped inner contour. In axial direction A, the ogival inner contour 203 of the projectile receptacle 205 preferably continuously merges into the ogival surface of the bottom side 213 of the point punch or face punch, in particular free of cracks and/or edges.

When the projectile blank with the projectile rear punch 207 is inserted into the projectile blank receptacle 205 relative to the bottom side 213 defined by the point punch, the metal material of the front case section 23 is deformed like an ogive so that projectile 2 is formed from the projectile blank. In the ogival-shaped final position, depicted in Figure 11, the ogival-shaped projectile 2 is made in sections from the projectile blank. The projectile 2 can then be reworked, for example, by levelling. The cylinder section 25 of projectile 2 is preferably not deformed during the ogival progress, so that it preferably retains its outer diameter completely, in particular according to the (caliber) projectile diameter D_z .

The pressing tools or presses (100, 101, 103, 200) can be equipped with mechanical limit switches and/or force-dependent limit switches and/or travel-dependent limit switches to define the relative position of the bottom side to the respective ram in the respective end position. Tool receptacles and dimensions can vary depending on the caliber, plant and/or embodiment of the tool.

The features revealed in the above description, in the figures and in the claims may be relevant, either individually or in any combination, to the realization of the invention in its various configurations.

Reference list

1, 1.1, 1.2, 1.3, 1.4	Solid projectile
1.5, 1.6, 2	Solid projectile
1a, 1b	Projectile blank
1x	Metallic blank
3, 23	Ogival portion
5, 25	Cylinder portion
3a, 5b	Sleeve portion
7	Stem portion
11	Opening
13	Tip
31, 31a, 31b	Ogival wall
32, 32a, 32b	Inner contour
33, 33b	Ogival cavity
34, 34a, 34b	Outer contour
35, 35a, 35b	Bottom
51	Deformation cylinder
53	Deformation cavity
55, 55a, 55b	Shaft
57	Microchannel
71, 71a, 71b	Rear
73, 71a, 71b	Calotte
75, 75a, 75b	Truncated cone section
100	Setting press
101	Preform press
103	Inner contour forming press
105a	Metallic blank receptacle
105b, 105x	Projectile blank receptacle
107a, 107b, 107x	Bottom side
111	Preform punch
112	Preform portion
113, 123	Front surface
115, 125	Guide section
121	Inner contour forming punch
122	inner contour forming portion

133	Sleeve forming section
200	Ogival forming press
203	Ogival portion
205	Projectile receptacle
207	Projectile rear punch
213	Bottom side
A	Rotational axis/Axial direction
R	Radial direction
d _o	Opening diameter
D _Z	Cylinder diameter
h _S	Stem height
h _{Ra}	Height (Preform cavity)
h _{Rb}	Height (Inner contour forming cavity)
l _G	Projectile length
l _H	Shaft height
l _o	Ogival portion height
l _s	Stem height
l _z	Cylinder section height

Claims:

1. Metallic solid projectile for practice cartridges, in particular for use on preferably police shooting ranges, wherein the solid projectile comprises an ogival portion at the front side and a cylinder portion for holding the solid projectile in a cartridge case and defines a projectile length in the axial direction,
 - wherein the ogival portion comprises an ogival wall and a rotationally symmetrical ogival cavity circumferentially bounded by the ogival wall,
 - wherein a fully cylindrical stem portion of the solid projectile extends in the axial direction over less than 45% of the projectile length,
 - wherein starting from a bottom of the ogival cavity, a shaft extends into the cylinder portion, which shaft forms a microchannel and/or a deformation cavity, and
 - wherein when the shaft forms a deformation cavity, the deformation cavity is shaped at least in sections to be cylindrical and/or at least in sections to be conical with a taper at the front side.
2. Solid projectile according to claim 1, characterized in that the ogival wall has an ogival wall thickness and the solid projectile forms an annular deformation sleeve wall in the cylinder portion in the axial direction at least in sections, which has a deformation sleeve wall thickness which is greater than the ogival wall thickness, preferably the ogival wall thickness being less than half the radius of the solid projectile and/or preferably the deformation sleeve wall thickness being less than or equal to the radius of the solid projectile.
3. Solid projectile according to claims 1 or 2, characterized in that the solid projectile is blunt at the front side and/or has an opening at the front side which opens into the ogive cavity and has an inner opening diameter which is greater than 0.5 mm, in particular greater than 1.0 mm, and/or is smaller than 3 mm, in particular smaller than 1.5 mm.
4. Solid projectile according to one of the preceding claims, characterized in that the fully cylindrical stem portion extends in the axial direction over less than 3 mm, less than 2 mm or less than 1 mm and/or that a calotte is recessed at the rear end of the solid projectile.

5. Solid projectile according to one of the preceding claims, characterized in that an inner contour surrounding the ogival cavity is completely rounded in the axial direction, preferably formed step-free and/or has exclusively rounded edges.
6. Tool arrangement for producing metallic solid projectiles for practice cartridges, preferably with a rotationally symmetrical ogival cavity, comprising a preform press having
an inner contour forming press having a hollow cylindrical projectile blank receptacle which is bounded in the axial direction by a bottom side,
a preform punch, having a preform section which tapers in the axial direction relative to a front surface, preferably at least in sections conically, in particular in the form of a truncated cone, and in particular rotationally symmetrical, the preform portion being movable relative to the bottom side for forming a projectile blank to a preform end position in which the preform punch, the bottom side and the projectile blank receptacle define a preform cavity for the projectile blank,
wherein in the preform end position, an axial distance between the bottom side and the front surface is less than 45% of a maximum height of the cavity in the axial direction, and
wherein the tool arrangement further comprises an inner contour forming press having
a hollow cylindrical projectile blank receptacle which is bounded in the axial direction by a bottom side, and
an inner contour forming punch comprising an inner contour forming portion extending axially to a front surface, said inner contour forming portion being movable relative to the bottom side for forming the projectile blank to an inner contour forming end position, wherein said inner contour forming punch, said bottom side and said projectile blank receptacle define an inner contour forming cavity for said projectile blank,
wherein, in the inner contour form end position, an axial distance between the bottom side and the front surface is greater than the axial distance between the bottom side of the preform press and the front surface of the preform punch in the preform end position.
7. Tool arrangement according to claim 6, characterized in that the front surface of the inner contour forming punch is formed as a blunt cone tip, in particular with a rounded front edge tip, and/or the inner contour forming portion is formed in sections in the axial direction as a sleeve forming section with an essentially cylindrical outer contour, in particular the inner contour forming portion having

adjacent to a guide portion of the inner contour forming punch a frustoconical transition portion extending radially from the inner contour forming portion to the guide portion.

8. Tool arrangement according to claims 6 or 7, characterized in that the tool arrangement further comprises a setting press having a hollow cylindrical metal blank receptacle bounded in axial direction by a bottom side and having a setting punch, which is movable relative to the bottom side for forming the metal blank up to a setting end position, in which the setting punch and the projectile blank receptacle form a setting cavity with a predetermined clear width for defining a constant outer diameter, in particular the caliber diameter, of the metal blank.
9. Tool arrangement according to one of claims 6 to 8, characterized in that the tool arrangement further comprises an ogival forming press which has a hollow cylindrical projectile receptacle which is bounded in the axial direction by a concave, ogival-shaped bottom side and which has a projectile rear punch for holding and/or centering the rear end of an internally contour-shaped projectile blank, which is movable relative to the bottom side for forming the solid projectile to an ogival shape end position, in which the projectile rear punch, the projectile receptacle and the bottom side define a cavity defining a projectile negative with an ogival portion and a cylinder portion adjacent thereto.

10. Method for producing metallic solid projectiles for practice cartridges, preferably with a rotationally symmetrical ogive cavity, in which
 - a metal blank formed in particular from cut-to-length metal wire is provided, preferably with a cylindrical outer surface,
 - wherein, in a preforming step, the metal blank is formed into a projectile blank with a sleeve-shaped portion which, at the end of the preforming step, extends over more than half of the greatest axial blank height, in particular the sleeve-shaped portion being formed with a preferably continuously tapering inner contour, the projectile blank is deformed after the preforming step in an inner contour forming step in such a manner,
 - that a front-side sleeve portion of the projectile blank is formed with a radially outer sleeve wall of substantially constant wall thickness and/or cylindrical inner contour,
 - that a rear-side sleeve portion of the projectile blank is formed with a shoulder projecting radially inwards from the sleeve wall, and
 - that a shaft starting from the shoulder is formed which extends into the rear-side sleeve portion of the projectile blank.
11. Method according to claim 10, characterized in that the metal blank is formed in the preforming step while maintaining a remaining fully-cylindrical stem portion of a projectile blank extending in the axial direction over less than 45% of the greatest axial blank height, or in that the metal blank is completely penetrated in the axial direction in the preforming step for forming the projectile blank.
12. Method according to claim 10 or 11, characterized in that the shaft forms a microchannel and/or a deformation cavity,
 - wherein when the shaft forms a deformation cavity, the deformation cavity is formed at least sectionally cylindrically and/or at least sectionally conically with taper at the end.
13. Method according to claim 12, characterized in that in the inner contour forming step the projectile blank is being formed in such a way, that the deformation cavity forms a waist-shaped constriction at the front side, wherein the microchannel is formed between the deformation cavity and the shoulder, in which microchannel the inner wall surface of the sleeve section is brought together flat in particular in contact, and/or that a distance in the axial direction between the shoulder and a rear becomes

greater than the axial height of the fully cylindrical stem portion of the projectile blank which may be present at the end of the preforming step.

14. Method according to one of the claims 10 to 13, characterized in that the projectile blank, after the inner contour forming step, is formed in an ogival forming step in such a way that the front side sleeve wall forms an ogival outer surface in sections, an opening being maintained at the front side which preferably opens into an ogival cavity defined circumferentially by the sleeve wall.
15. Method according to one of the claims 10 to 14, characterized in that the preforming step, the inner contour forming step and/or the ogival forming step are carried out without cutting, in particular by cold forming, preferably by pressing.