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Concept MSBS GROT Rifle Upper Receiver Shield to Protect Against Foreign Objects

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Abstract. This paper presents a concept for shielding the MSBS (Modular Firearms System) Grot rifle upper receiver against foreign objects. The concept guidelines involve feedback from Grot operators concerning the regular operation of the rifle plus an extensive analysis of desktop patent research into foreign debris shields (or dust shields) for protection of the upper receiver interior in firearms. The completed patent desktop research included solutions used with automatic, semi-automatic and non-automatic firearms. The research work drove the formulation of the requirements for an upper receiver dust shield for the 5.56 mm calibre MSBS Grot rifle as part of the ongoing improvement process. This paper presents three concepts of the carrier charging handle assembly dust shield (for the protection of the upper receiver against foreign objects) for the MSBS-5.56 rifle system. The concepts described vary in terms of the level of structural complexity of the dust shield, and the extent of the modifications required to the upper receiver of the rifle.

With test units of the upper receiver dust shield manufactured and comparative tests completed on the three concepts, the version selected should be the one which improves the protection of the rifle internals from foreign objects found in the local environment, including sand, clay, silt, and mud, the latter being an aqueous suspension of these particles.
Keywords: environmental factors, small arms, weapon design, weapon tests

1. INTRODUCTION

At the end of 2017, the Polish Armed Forces introduced the MSBS GROT 5.56 mm calibre standard (basic) rifle, version A0, with design specifics and applied proprietary solutions as discussed in [1, 2]. Prior to this, the MSBS rifle had successfully passed preliminary testing (at the manufacturer's) and (official) qualification testing, which confirmed that the rifle satisfied all tactical and technical requirements. Select units of the Polish Territorial Defence Force (TDF) and units under the Special Forces Component Command (SFCC) in 2017 undertook introductory testing of the MSBS GROT rifles to gather as much feedback and as many observations from the operators as possible for consideration during downstream improvement assays. The in-operation experiences of the rifle users have since been collected and examined, generating conclusions for the further development of the MSBS Grot rifle, which are formulated during regular sessions held by the TDF Command, which is the Military Ordnance Utility responsible for modular firearm systems in the Polish Armed Forces [3]. The regular MSBS development sessions include the attendance of representatives from the TDF Command, the SFCC, the Armament Inspectorate, the Armed Forces Support Inspectorate, 3 Regional/District Military Representation, the Military University of Technology (MUT, Warsaw, Poland), and the MSBS Grot manufacturer, Fabryka Broni Łucznik-Radom (FB Radom, Poland). The deliverables from the regular MSBS sessions so far have included the design modifications successfully implemented in the MSBS GROT rifle from versions A0 through A1 and A2 [4]. The modifications especially improved the operating comfort of the Grot rifle under various operating scenarios.

During a regular MSBS development session an issue was raised for the application feasibility of an upper receiver dust shield for MSBS firearms, which include the MSBS GROT standard rifle. The implementation of an upper receiver dust shield would improve the reliability of the rifle primarily under extreme operating conditions (with exposure to sand, clay, silt, and water suspensions of these – mud). Considering the foregoing, the MUT design team studied the issue (shown in [5]) so that it might be resolved as part of the next evolution of the MSBS GROT.

2. ANALYSIS OF UPPER RECEIVER DUST SHIELD SOLUTIONS

The issue of protecting the internal mechanisms of firearms against environmental debris has been known since the very origins of firearms. However, the emergence of automatic firearms with much higher levels of mechanical complexity (compared to non-automatic firearms) has escalated the problem of foreign debris ingress. A sufficient quantity of any foreign debris entering a firearm can jam its mechanical internals. Providing a seal for the upper receiver against foreign debris is a critical issue, one which should be considered at the design stage for a new firearm (and no requirement of such relevance was established in the tactical and technical requirements for the MSBS Grot). An extensive analysis of the solutions intended to minimise the risk of ingress of foreign debris into the upper receiver of automatic firearms revealed that there are many methods for mitigating the risk [5].

The simplest method of protecting the upper receiver internals were pouches (made of webbing, for example) for the entire firearm or its critical components, mainly the upper receiver. Another and a definitely more effective protection method that remains very common today is the application of moving shields integrated into the structure of a firearm. Not only does this solution provide very good protection of the mechanical internals against foreign debris, but it also facilitates (in most cases) quick deployment for shooting.

Initially, manually opened and closed shields were used, especially in semi-automatic firearms. A typical example of the dust shield like this is the fire/safety selector lever in the AK family of rifles, which when lifted to its dead top (safety on), it covers the breech cover opening which accommodates the carrier charging handle, and which moves to and fro while discharging rounds. In automatic firearms, the manually opened dust shields were gradually replaced with automatic counterparts which were synchronised with the movement of other mechanical components and covering the upper receiver holes, including the case ejection port, the magazine receiving port, or the feeder ports (in belt-fed firearms) or the carrier charging handle slot (which reloads the firearm chamber).

One of the former solutions which is used today is a dust shield formed by a strip connected to the charging handle (which is stationary during firing) and covering the slot (port) in the left-hand wall of the upper receiver assembly. This concept, implemented in the M1918 Browning Automatic Rifle (BAR) [6] was complemented soon after with manual positioning of the case ejection port [7] and the magazine receiver port [8]. A complement of this type of foreign debris protection was implemented in the light machine gun (type 1928) manufactured under license in Poland (Photo 1). In the interwar years, a solution emerged that was dedicated to closed breech bolt designs, where the dust shield opening was initiated directly by the backward movement of the breech bolt or carrier.

This helped to keep the dust shield closed until a round discharge was complete and the breech bolt began reversing, while making feasible the application of a system where the carrier charging handle remained stationary when firing. One mass-produced firearm pattern to feature this specific solution was the German Sturmgewehr 44 and its variants.

Photo 1. Breech bolt receiver of the light machine rifle type 1928

The solutions featuring the case ejection port shields found more widespread use in different designs of firearms after World War Two, such as the AR15/M16 family of U.S. rifles and their derivatives, or the German HK G41 and HK 416 automatic rifles (Photo 2). Moreover, the carrier charging handle of the AR15, which extends back out of the upper receiver, protects the upper receiver internals very well against foreign debris.

Photo 2. M16A1 rifle upper receiver: the case ejection port shield is shown open with the carrier charging handle

By virtue of their simplicity, automatic operation and effectiveness, automatically opening dust shields are now used in many firearm designs. Their primary drawback is that they need to be closed automatically after firing. There have been several firearm designs which have included attempts to eliminate this issue. They include a specific solution used in the Soviet-era family of PK/PKM machine guns.

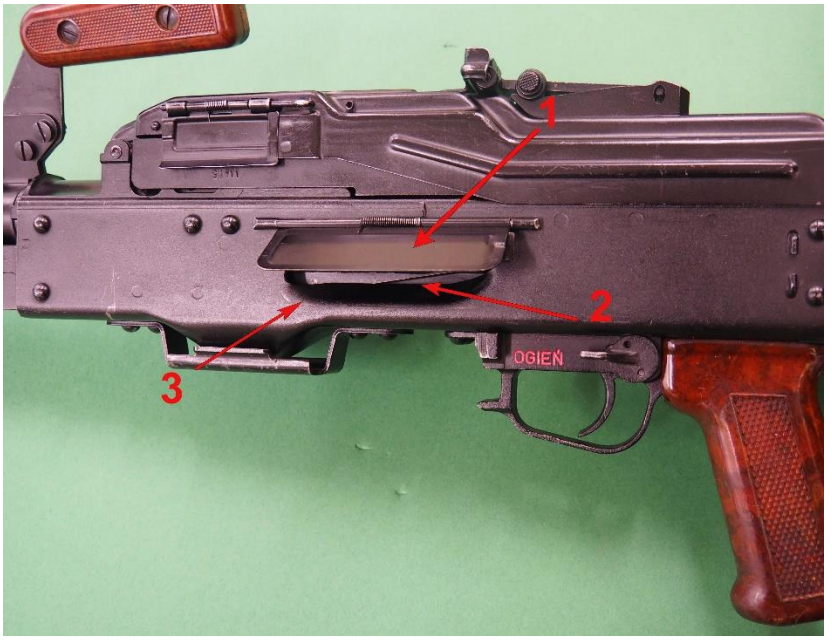

Photo 3. PKM general-purpose machine gun breech bolt receiver: 1 – case ejection port, shown open; 2 – dust shield opening lever, shown extended; 3 – bolt carrier assembly, shown moving forward

When the case ejection port shield is opened (Photo 3), the operating component is the side surface of the bolt carrier which initiates the opening motion as it moves backward. The engagement of the dust shield is provided by a lever inside the breech bolt receiver, which not only helps open the dust shield, but also (and by maintained contact with the bolt carrier surface) keeps the dust shield open until the moving assembly returns to the forward position. When the forward position is reached, the bolt carrier disengages from the lever and the support spring closes the dust shield. Both feeder ports are protected by automatically closing shields which are tilted open with the ammunition belt loaded. The carrier charging mechanism resides in a purpose-shaped guide on the right-hand side of the breech bolt receiver and its linkage enters the breech bolt receiver from the front-end of the guide, while continuously covering the slot (Photo 4).

Photo 4. PKM general-purpose machine gun breech bolt receiver: 1 – carrier charging handle; 2 – guide

A very interesting solution was implemented with the SIG 550 rifle series, where the carrier charging handle is combined with the bolt carrier, as with AK rifles. The dust shield for the carrier charging handle slot is formed by two long, flexible shields in contact with the handle along the full travel of the recoil assembly (Photo 5 and Fig. 1).

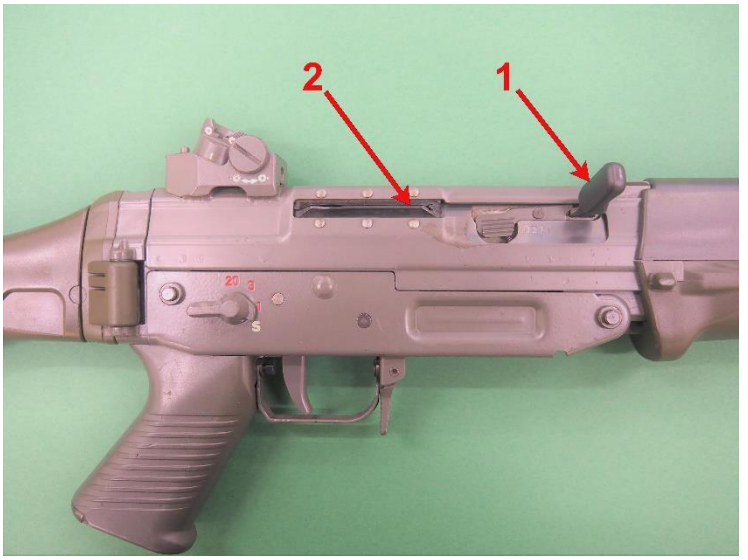

Photo 5. SIG 552 rifle upper receiver: 1 – carrier charging handle; 2 – guide

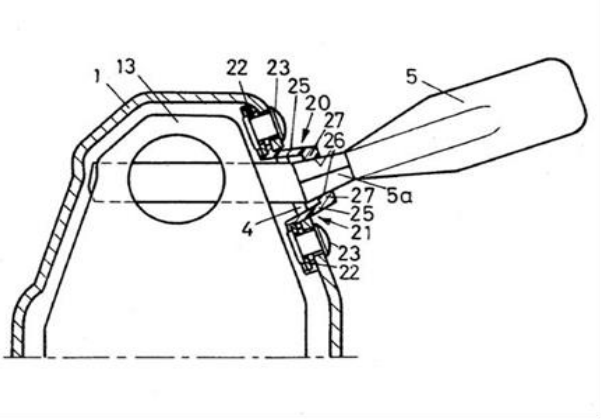

Fig. 1. Details of the US4443962 patent solution – cross-sectional view of the upper receiver [9]

Another unique solution is used in the FNC rifle series and the MINIMI submachine rifle (manufactured by FN HERSTAL), where the carrier charging handle is linked to the bolt carrier while discharging rounds. The slot for the carrier charging handle is a moving metal plate outside the breech bolt receiver for the FNC or the breech bolt cover for the MINIMI. The dust shield is closed by the action of a purpose-designed retaining spring (Photo 6 and Fig. 2).

Photo 6. MINIMI machine gun breech bolt receiver

Another design from FN HERSTAL, the SCAR modular system (specifically, the 5.56 mm calibre SCAR-L, see Photo 7, and the 7.62 mm calibre SCAR-H) do not feature any additional components to shield the breech bolt receiver from foreign debris.

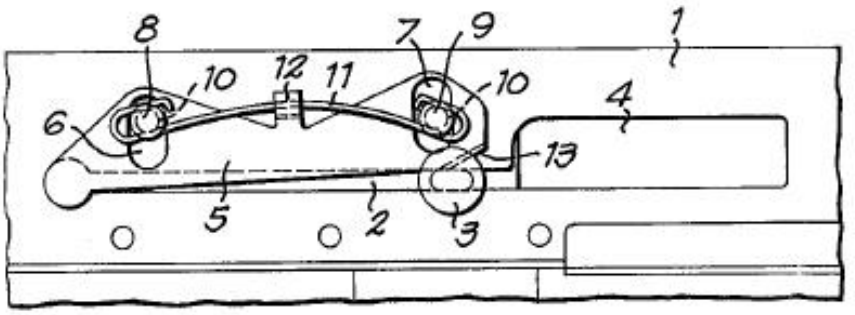

Fig. 2. Details of the US4145831 patent – the dust cover is lifted by the movement of the carrier charging handle [10]

Photo 7. FN SCAR-L rifle breech bolt receiver

Both sides of the upper receiver feature two lengthwise slots (to make way for the carrier charging handle) which partially cover the upper portion of the bolt carrier, any position of which covers the slots. The bolt carrier has a crosswise port to accommodate the carrier charging handle from either side of the rifle.

The moving carrier charging assembly of the SCAR rifles is deemed to be a considerable flaw of the weapons; and an alternative solution was developed by ADCOR, featuring a fixed carrier charging handle which enables temporary (and as intended by the rifle's operator) engagement of the carrier charging assembly with the bolt carrier to, for example, feed a cartridge into the chamber with a partial displacement of the recoiling assembly into the dead forward position. The patent application [11] specifies a slider which is the base for all carrier charging assembly components and engaging the top part of the bolt carrier.

The slider and the top part of the bolt carrier have specific forms and dimensions to double as a dust shield for the carrier charging handle slots in the breech bolt receiver (Fig. 3).

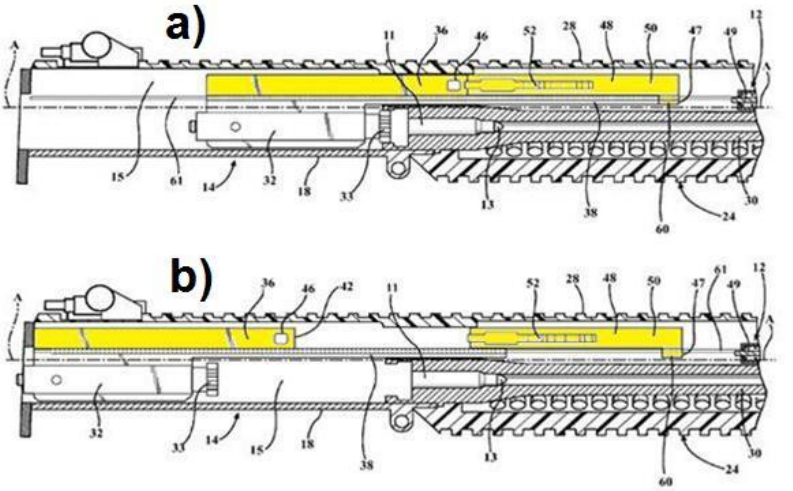

Fig. 3. Location of the shield for the carrier charging handle slots in the cross-sectional view of the breech bolt receiver: a – before discharge (slider and bolt carrier are engaged); b – after discharge (slider disengaged from the bolt carrier), ref. US2013174457 patent application [12]

A quite different solution was presented in patent application [12], which specifies the engineering of a twin carrier charging assembly for a design based on an AR15 family-derived breech bolt receiver and recoil assembly (Fig. 4 and 5). A characteristic feature of the solution is an additional carrier charging handle (stationary while discharging a round) on the left-hand side of the upper receiver to make recharging of the weapon easier and faster than with the standard solution for the AR15. The carrier charging handle slot is covered by a dust shield in the form of a slat.

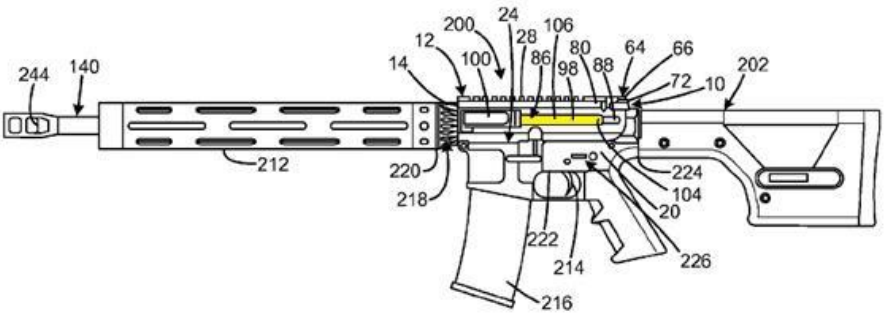

Fig. 4. AR15 with the additional carrier charging handle and a long dust shield (shown in yellow) [12]

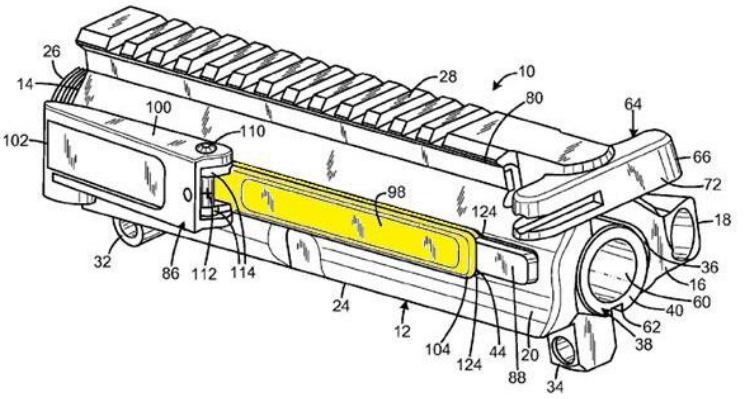

Fig. 5. Long dust shield of the AR15 additional carrier charging assembly (shown in yellow) [12]

The completed patent desktop research proved that methods exist for the protection of the upper receiver interior against foreign debris. The solutions provided by the methods can be classified into several groups. Special attention is deserved by flexible dust shields, automatically opened dust shields, and carrier charging assembly dust shields.

3. BASIC REQUIREMENTS FOR THE UPPER RECEIVER DUST SHIELD OF THE MSBS-5.56

The upper receiver of the MSBS-5.56 in the area of the guide slot of the carrier charging handle is shown in Figs. 6 to 8.

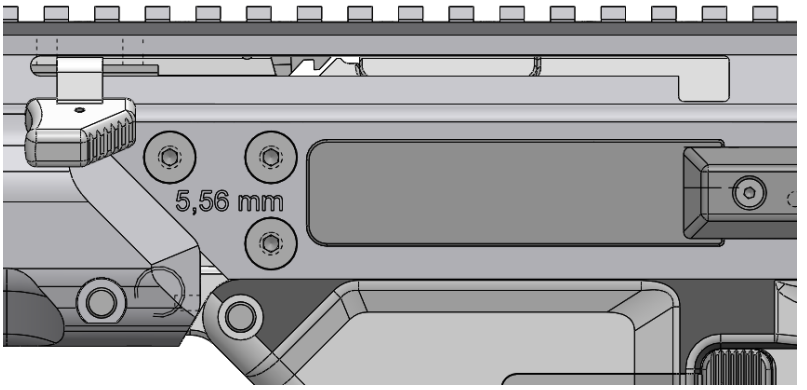

Fig. 6. Breech bolt receiver section of the MSBS Grot with the guide slot for the carrier charging handle; carrier charging assembly and the bolt carrier are forward (shown from the left-hand side)

In the forward position of the bolt carrier and the carrier charging assembly (Fig. 6), the guide slot partially exposes the end part of the carrier charging assembly with the latch (which engages the mating reliefs of the barrel housing) and the top part of the bolt carrier.

In the rearward position of the bolt carrier and the carrier charging assembly (as in manual reloading of the firearm, see Fig. 7), almost the whole guide slot is open. This also occurs when the carrier charging assembly is in the forward position and the bolt carrier is in the rear (on its latch when the last cartridge from the magazine has been discharged, see Fig. 8).

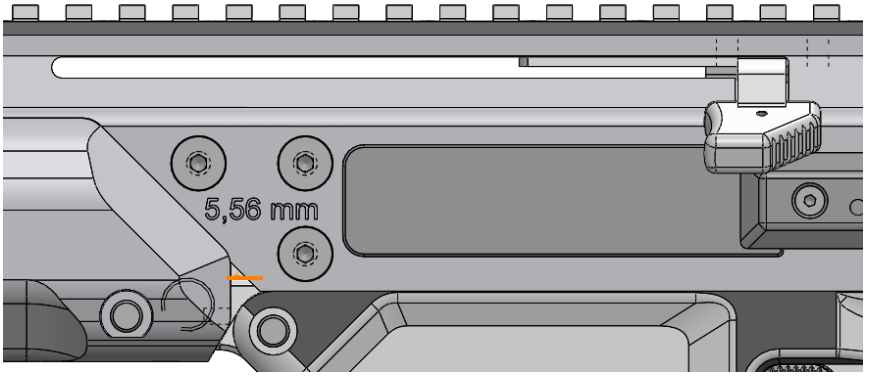

Fig. 7. Breech bolt receiver section of the MSBS Grot with the guide slot for the carrier charging handle; carrier charging assembly and the bolt carrier are rearward (shown from the left-hand side)

Note that this solution does not differ significantly in the efficiency of upper receiver protection found on other modern rifles, including the ČZ 805 BREN, the HK G36, or the HK 433. These firearms do not feature case ejection port covers, although the upper receivers have carrier charging handle slots which are exposed as the bolt carrier moves.

A higher degree of foreign debris protection is provided in the SCAR and the ČZ 807 BREN 2 rifles, where the SCAR keeps the guide slots closed by extension of the bolt carrier, while the BREN 2 features a carrier charging assembly designed to protect the inlet side of the barrel. Better protection against foreign debris is also provided by an AR15-derived rifle design (which includes the HK416 and the SIG MCX) which has covers on the case ejection ports and a centrally located carrier charging assembly, the handle of which (with the assembly in the forward position) closes the breech bolt carrier port in which the charging handle extends to the outside. This carrier charging assembly does not favour ergonomic operation and it is seen as a design flaw.

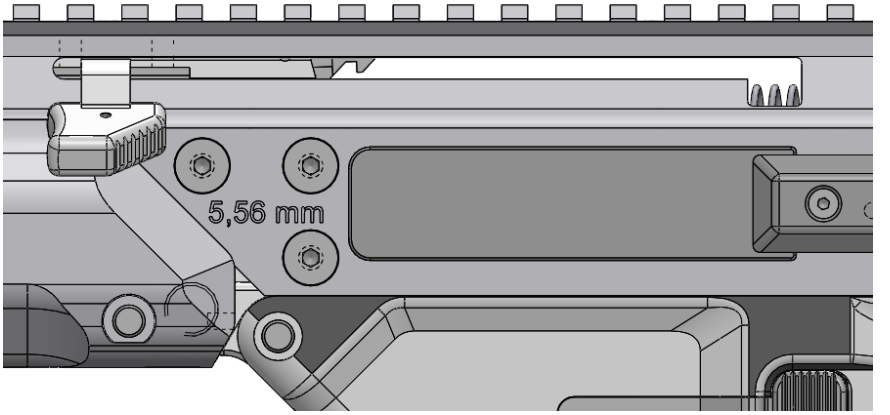

Fig. 8. Breech bolt receiver section of the MSBS Grot with the guide slot for the carrier charging handle; carrier charging assembly is forward and the bolt carrier is rearward (shown from the left-hand side)

Based on the study of the MSBS Grot 5.56 mm standard rifle design, the carrier charging dust shield should meet the following main requirements:

1. Provide effective protection of the upper receiver internals, which comprise the moving assembly (the breech bolt with its carrier), its guide ways, and the carrier charging assembly, against ingress of all foreign debris from the soil (e.g. sand, clay, and silt) or mud.
2. Must not obstruct (negatively affect) the reliable automatic action when the rifle exterior becomes dirty when discharging rounds.
3. Facilitate reloading of the rifle when dirty (by operating the carrier charging handle) without exposing the breech bolt receiver interior (especially around the magazine receiver port, the locking sleeve abutment, and the cartridge chamber) to secondary contamination with foreign debris from the exterior of the rifle.
4. Must not interfere with correct automatic action of the dirty rifle once the reloading action has been operated.
5. Ensure minimum modification of the rifle design while retaining the maximum of its original components.
6. Facilitate implementation of the dust shield solution in all MSBS firearm types (stocked and bullpup).

4. CARRIER CHARGING HANDLE ASSEMBLY DUST SHIELD CONCEPTS FOR THE MSBS-5.56

4.1. Concept A

Concept A provides for a partial coverage of the guide slots of the carrier charging handle with straps (a left-hand one shown in Fig. 9 and its mirror counterpart for the right-hand strap), each attached to both sides of the carrier charging assembly and moving with the same assembly.

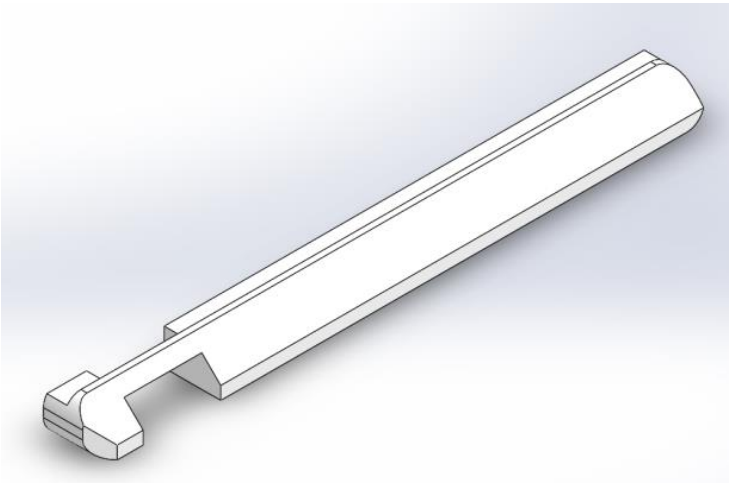

Fig. 9. LH strap of the carrier charging assembly

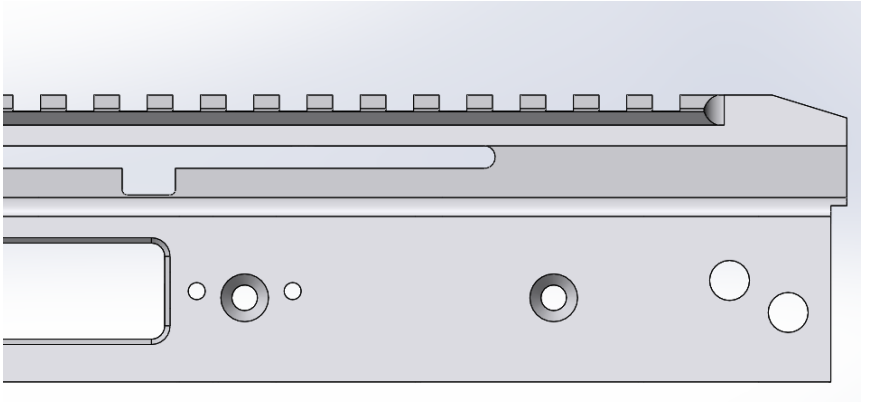

Fig. 10. Portion of the upper receiver casing in the MSBS-5.56 rifle shown with the extended guide slot of the charging handle

The addition of the side straps to the carrier charging assembly will force an extension of the guide slots towards the stock holder (Fig. 10), exposing the interior of the breech bolt receiver over the percussion firing action of the lower receiver assembly, portions of the bolt carrier shields, and a part of the return action.

When the charging handle remains in its forward position, the charging assembly strap covers the front part of the guide slot which should shield the carrier charging latch against dirt and jamming (Fig. 11). The remainder of the guide slot remains open to foreign debris ingress into the bolt carrier chase (which serves to facilitate the breech bolt control pin), the return action, and the percussion firing action.

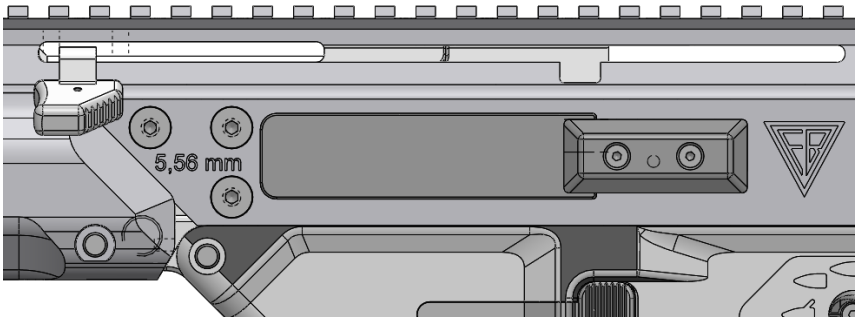

Fig. 11. Breech bolt receiver section of the modified MSBS-5.56 (Concept One); carrier charging assembly and the bolt carrier are forward
(shown from the left-hand side)

4.2. Concept B

Concept B provides for shielding almost the entire length of the guide slots of the carrier charging handle with two rubber strips retained by metal straps riveted to the upper receiver assembly (Fig. 12). The rubber strips fully cover the guide slots and protect the upper receiver/breech bolt receiver interior from foreign debris.

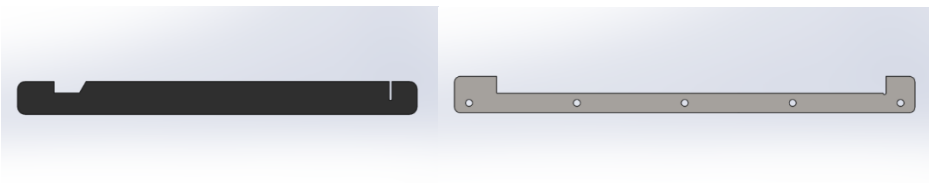

Fig. 12. Rubber strip (see left) with its strap on the carrier charging handle guide slot (see right)

The attachment of the strips and straps will require a suitable design modification of the upper receiver casing (Fig. 13) by opening chases (to avoid any increase in the size of the upper receiver) and fabricating rivet holes. The rivets in this concept could be replaced with another fastener type.

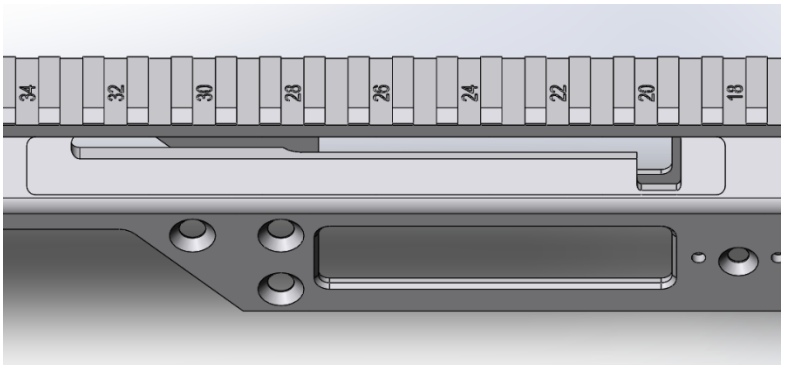

Fig. 13. Recess in the modified upper receiver casing (Concept B) for the attachment of the strip and strap assembly

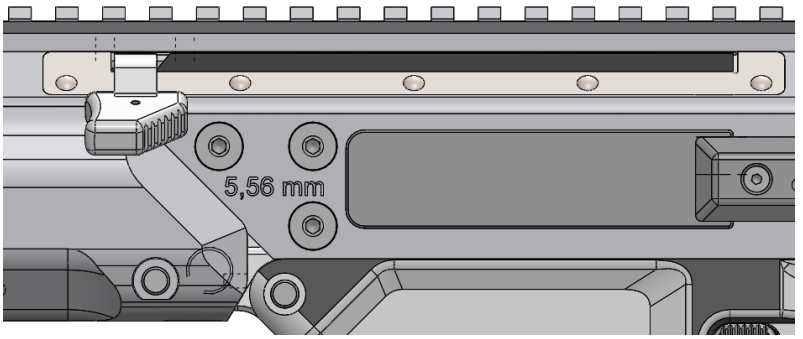

Fig. 14. Breech bolt receiver section of the modified MSBS-5.56 (Concept B); the carrier charging assembly and the bolt carrier are forward (shown from the left-hand side)

When the charging handle remains in its forward position, the rubber strip covers the entire guide slot, which should effectively shield the upper receiver interior from foreign debris (Fig. 14).

4.3. Concept C

Unlike the two concepts discussed above, Concept C provides for a radical modification of the rifle design by relocating the guide slot of the carrier charging handle forward, ahead of the barrel housing.

This modification of the upper receiver casing (Fig. 15) will force a modification of the carrier charging assembly (primarily by extending the carrier length, see Fig. 16) and elimination of the collision between the carrier charging assembly with the barrel assembly, which is feasible by a slight modification to the dimensions of existing parts.

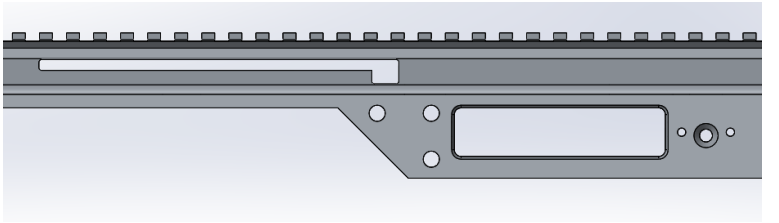

Fig. 15. Upper receiver casing section of the modified MSBS-5.56 (Concept B) (shown from the left-hand side)

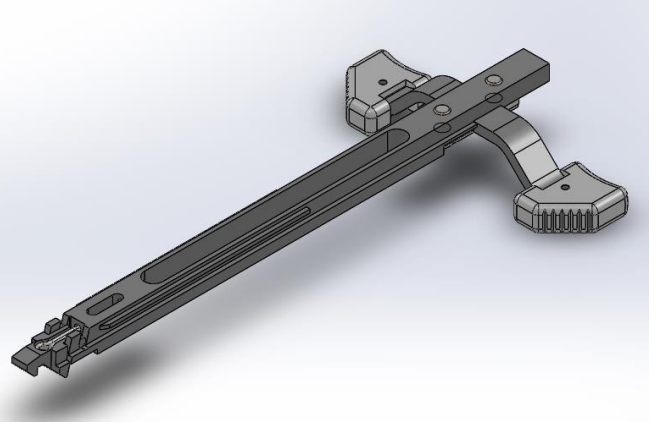

Fig. 16. Carrier charging assembly of the modified MSBS-5.56 (Concept C) (isometric view)

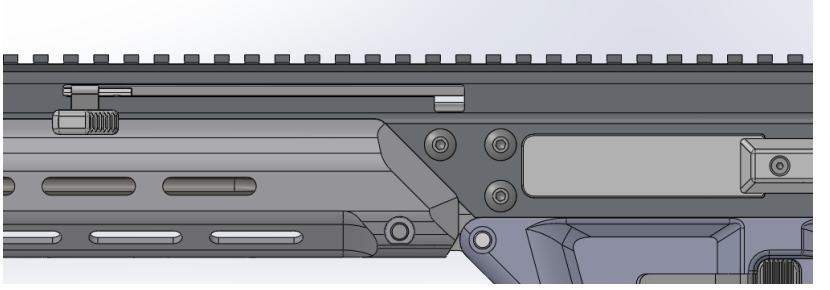

Fig. 17. Breech bolt receiver section of the modified MSBS-5.56 (Concept C); carrier charging assembly and the bolt carrier are forward (shown from the left-hand side)

Hence, the guide slots are open but the upper receiver interior which houses the moving assembly, the return action, and the carrier charging assembly rear part with the latch is fully shielded by the modified upper receiver casing (Fig. 17).

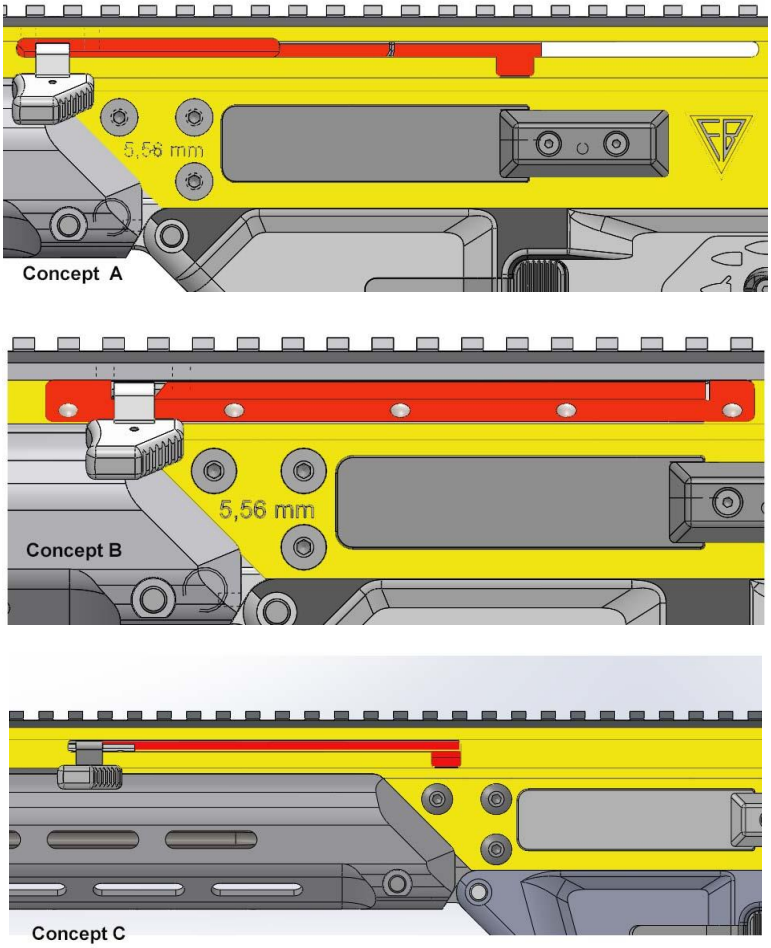

Fig. 18. Concepts of the MSBS GROT rifle upper receiver dust shields

To evaluate the ergonomics of the prospective design modifications provided for in Concept C, a 3D model would have to rapid-prototyped for the modified rifle.

Figure 18 lists the three concepts for the carrier charging handle assembly dust shield of the MSBS GROT rifle. This allowed a synthetic imaging of the extend of the design modifications of the rifle necessitated by each concept. Yellow shows the modified components, red shows new components.

5. CONCLUSIONS

Based on the analysis of the state of the art in the protection of upper receiver internals against foreign debris and the analysis of the MSBS Grot rifle design, a part of the Polish 5.56 mm calibre MSBS-5.56 (Modular Firearms System), it was found that many ways exist for the dust shielding of the upper receiver/carrier charging handle assembly.

Of the three concepts presented here for the dust shield of the carrier charging handle assembly, Concept A satisfies requirements (2) and (5) only. Concept B seems to satisfy all requirements, while Concept C requires relatively significant design modifications of the MSBS GROT.

Between Concept B and C, the latter is the most complex choice, yet it should fully protect the upper receiver interior against foreign debris.

Test models of the MSBS-5.56 rifles with the Concept B and C dust shields should be produced and undergo comparative testing.

Concept B, being a slight modification of the existing design, will require a lower workload (compared to Concept C) and will largely reduce the extent of testing. It can also provide protection of the upper receiver interior from foreign debris of soil/mud without significant modifications of the firearm design.

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Koncepcja zabezpieczenia przed zanieczyszczeniem wnętrza komory zamkowej karabinka MSBS GROT

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Streszczenie. W artykule przedstawiono koncepcje zabezpieczenia przed zanieczyszczeniem komory zamkowej karabinka MSBS Grot. Założenia koncepcji wynikają między innymi z formułowanych przez użytkowników karabinków Grot wniosków wynikających z bieżącej eksploatacji karabinka oraz szerokiej analizy badań patentowych w dziedzinie osłon zapobiegających zanieczyszczeniu wnętrza komory zamkowej broni strzeleckiej. Przeprowadzone badania patentowe obejmują rozwiązania zastosowane w broni powtarzalnej, samopowtarzalnej i samoczynnej, opracowanej w XX wieku. Na ich podstawie sformułowano wymagania, jakie powinna spełniać osłona zapobiegająca zanieczyszczeniu wnętrza komory zamkowej karabinków wchodzących w skład Modułowego Systemu Broni Strzeleckiej kalibru 5,56 mm który jest konsekwentnie udoskonalany. W artykule zaprezentowano trzy koncepcje rozwiązania przysłony zespołu napinacza broni systemu MSBS-5,56. Przedstawione w artykule koncepcje różnią się zarówno stopniem złożoności konstrukcji osłony jak i zakresem zmian które należy wykonać w konstrukcji komory zamkowej karabinka. Po wykonaniu modeli osłon i przeprowadzeniu badań porównawczych należy wybrać taki wariant osłony, który powinien zwiększyć odporność wnętrza broni na działanie czynników środowiskowych takich jak: piasek, glina, ił lub ich wodnych zawiesin - błota.
Słowa kluczowe: czynniki środowiskowe, broń strzelecka, konstrukcja broni, badania broni