PROFILE AFV WEAPONS 28

S-Tank

By R. M. Ogorkiewicz

AFV/Weapons Profiles

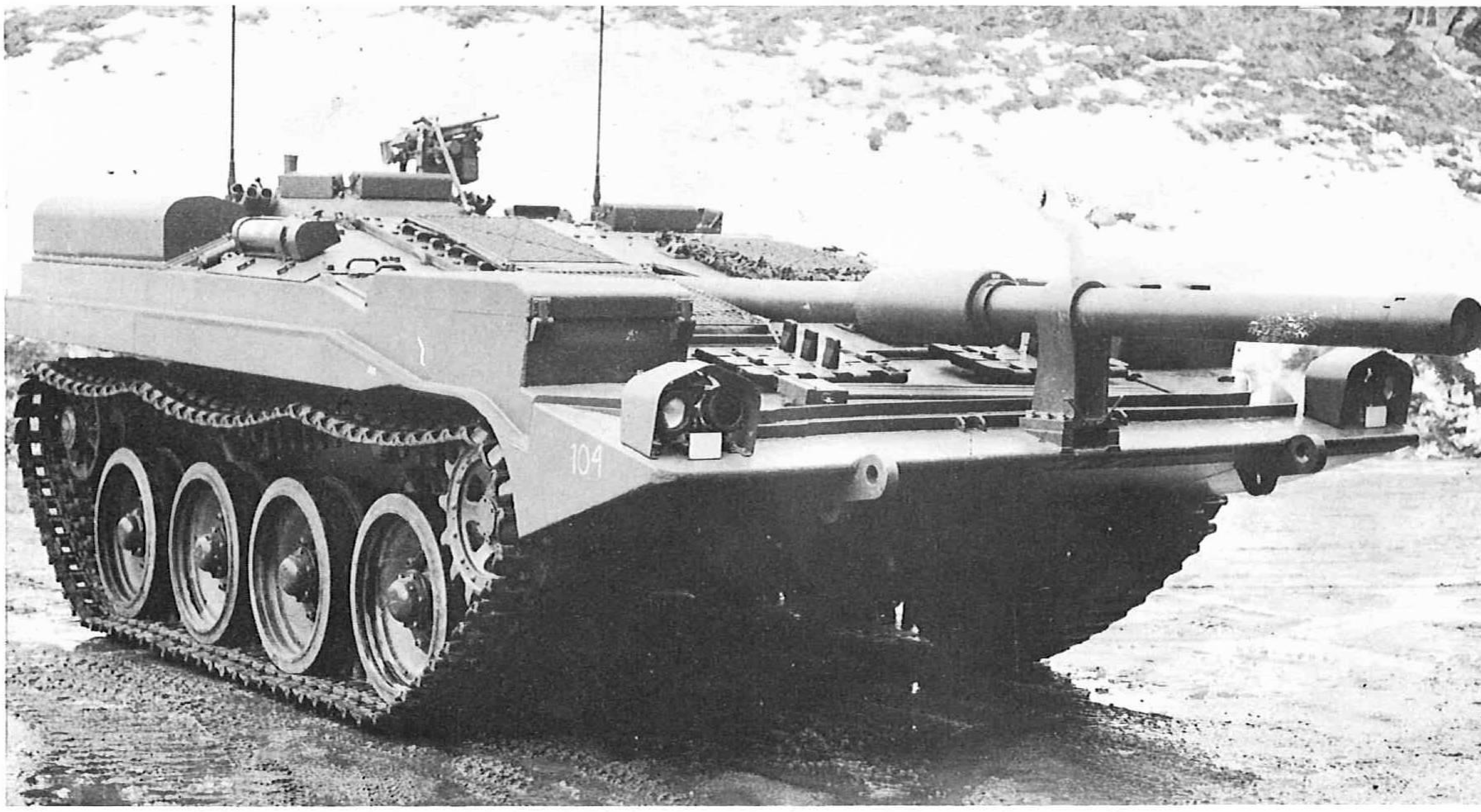
Edited by DUNCAN CROW

Check list of published titles:

Parts 1–17 price 25p each from your local book or model shop. Part 18 onwards price 35p each.
Retail prices in USA 1–17 $1·25. 18 onwards $1·50.

If you have any difficulty in obtaining Profiles from your local book or model shop please write direct to:

Mail Order/Subscription Department,
PROFILE PUBLICATIONS Ltd, Coburg House, Sheet Street, Windsor, Berks. SL4 1EB



Original production version of Strv 103, or S-tank type A, without flotation gear.

S – Tank

By R. M. Ogorkiewicz

Tank design has tended to follow a well-established pattern. In consequence, battle tanks resemble each other to a large extent. But there are exceptions to this, the most notable being the controversial Swedish S-tank which differs in many important respects from all other tanks.

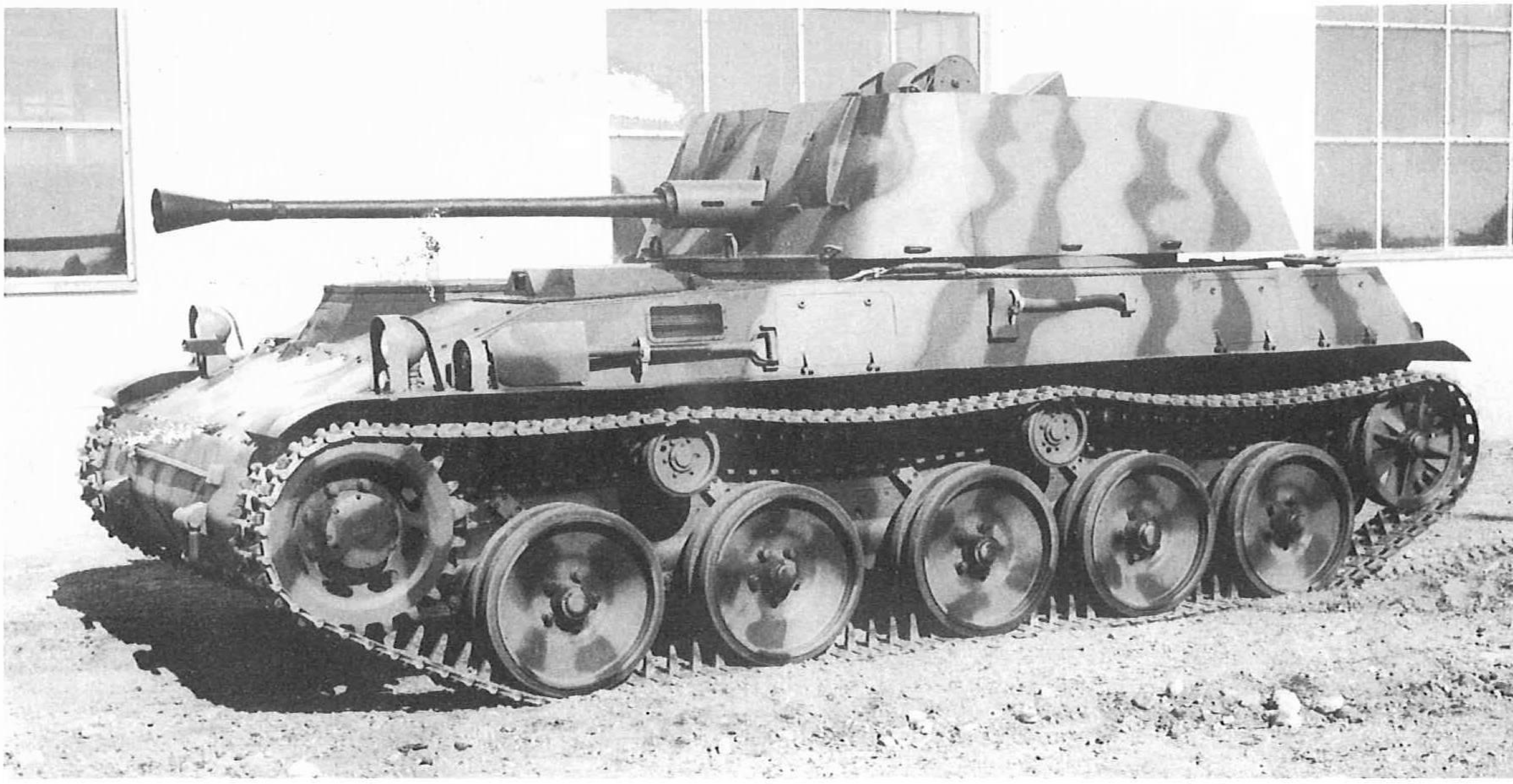
The most obvious feature of the S-tank is its lack of a turret. This alone makes it unconventional but does not, in itself, represent anything new. In fact, the very first tanks were turretless and so have been many others. What makes the S-tank different and an advance on all the earlier turretless vehicles is that the mounting of its gun is fixed in relation to the hull. As a result, it possesses several important advantages over other, more conventional, turreted as well as turretless vehicles.

Because it has no turret, the S-tank is considerably lower than conventional, turreted tanks, which makes it a more difficult target to hit. Moreover, its fixed gun mounting has eliminated the need for the space required within the armour envelope of turreted and even more of turretless vehicles by the movement of the breech end of the gun. The fixed gun mounting has also made it possible to install a relatively simple automatic loading mechanism, since it eliminates angular movement between the gun and the ammunition magazine. This, in turn, made it possible to dispense with the human loader and thus save a considerable amount of space within the vehicle, making the S-tank even more compact and consequently also lighter.

These and other advantages of the S-tank imply, however, that its gun can only be elevated or depressed by altering the pitch of the hull and traversed only by turning the whole vehicle. In other words, its gun can only be aimed by moving the whole vehicle. This had not been done before and it was only after several years of development that this method was successfully established.

ORIGINS OF THE DESIGN

Ideas which led to the S-tank originated with Sven Berge, the head of the tank design section of the Vehicle Division of the Swedish Army Ordnance. They arose out of his studies of tanks which had been produced by the early fifties and especially of the French AMX–13. At the time the Swedish Army actually considered purchasing this light tank from France although in the end it bought the more powerful Centurions from Britain. Nevertheless, some features of the AMX–13 attracted Berge, as they did other tank designers. In particular, he recognised the advantages of AMX–13's novel oscillating or trunnion-mounted turret. This allowed the gun to be mounted closer than ever to the turret roof, so that the tank needed to expose itself less when firing, and simplified fire control equipment and the installation of an automatic loading mechanism, because the gun did not move in relation to the optical instruments and the ammunition magazine. All these advantages accrued from the fact that the gun of the AMX–13 was fixed in the upper part of its two-piece oscillating turret and was elevated or depressed with it. However, the oscillating turret also had its disadvantages



Lvkv 42, an experimental 40-mm. self-propelled anti-aircraft gun with an adjustable suspension built by Bofors in 1954.

and this led Berge to propose an alternative way of exploiting its good features in the form of a turretless vehicle with a fixed gun mounting.

The origin of the ideas which led to the S-tank is particularly interesting because in retrospect it appears as a logical development of the earlier assault guns and other turretless vehicles. In fact, historically and from other points of view it is at least as much a development of turreted tanks, with the turret mounted directly on a tracked suspension.

PRELIMINARY INVESTIGATIONS

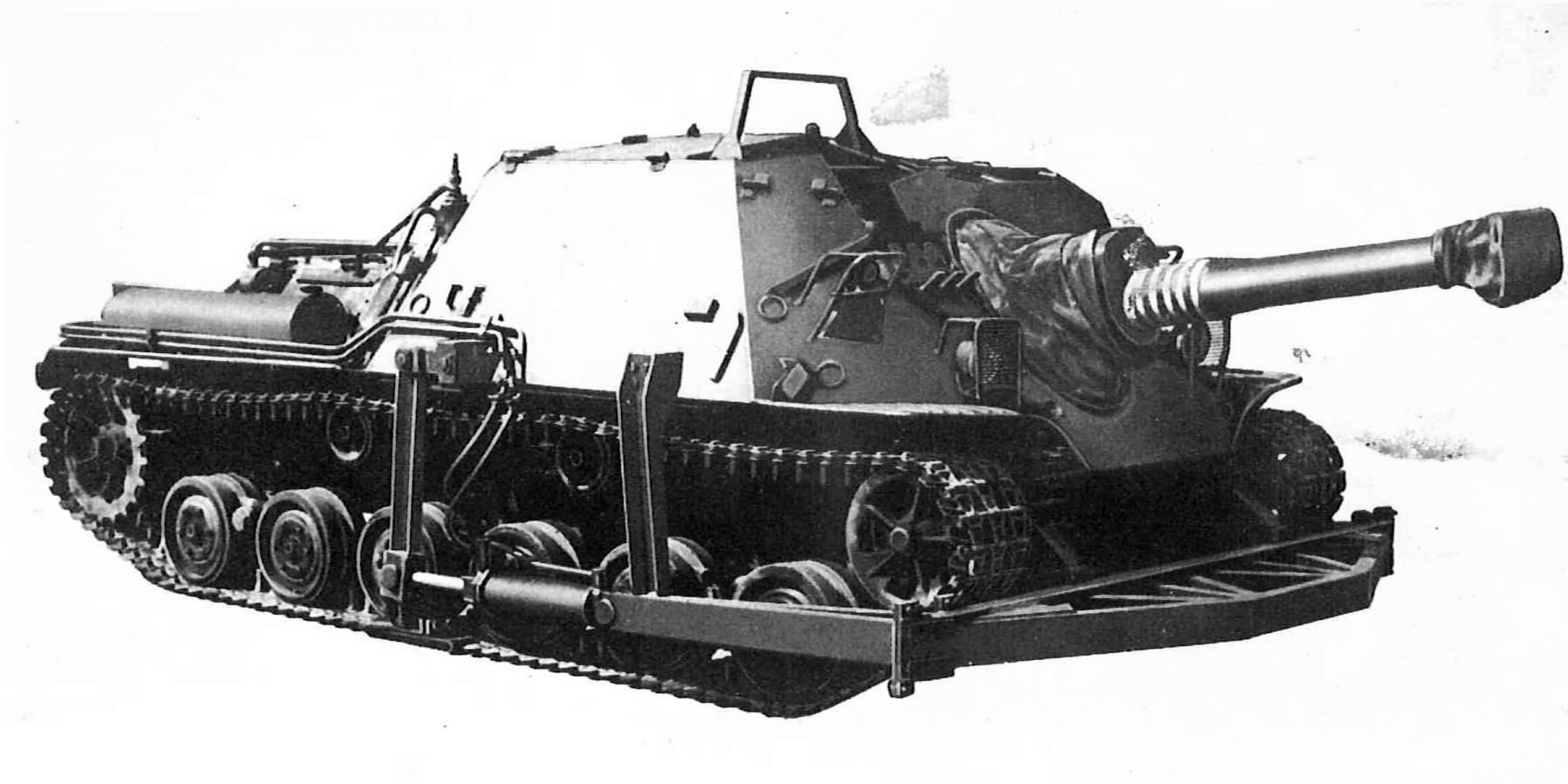
Berge put forward his original proposal in August 1956. At the time some of the concepts embodied in it had already been partly proved and this had, in fact, contributed to the formulation of the proposal. In particular, AB Bofors, the Swedish company world-famous for its guns, developed between 1949 and 1954 an experimental self-propelled 40-mm. anti-aircraft gun with an adjustable hydro-mechanical suspension which showed the feasibility of elevating or depressing a gun by altering the pitch of the hull in which it was mounted. The feasibility of traversing the gun by turning a vehicle was less clear. That the gun could be swung rapidly using a vehicle's clutch-and-brake steering system was shown several years earlier when the Swedish Army tested a German assault gun, the *Sturmgeschütz III,* as well as several other foreign vehicles acquired for evaluation purposes after the Second World War. But whether the gun could also be traversed sufficiently smoothly and accurately remained to be proved: the *Sturmgeschütz* and all but one other vehicle with hull-mounted guns could move them to a limited extent in relation to the hull for fine traverse.

The one exception was the French *Char B* of the thirties. This battle tank had a hull-mounted 75-mm. gun which was elevated independently of the hull but which was traversed by turning the vehicle by means of a double-differential steering mechanism with a hydrostatic steering drive. The steering system was derived from the SRB experimental tank designed in 1921 under the direction of E. Brillié, of the Schneider company, who had designed the first French tank. It provided a positive, infinitely variable degree of control over the speed of the tracks which made it superior for many years to other steering systems. However, in spite of the excellent steering system, the method of aiming the 75-mm. gun of the *Char B* by turning the whole tank did not prove entirely satisfactory after the tank was put into service in 1936 and was eventually abandoned. Thus on the final *Char B1 ter* version, of which only five were built before the French Army was defeated in 1940, the gun was no longer fixed in traverse but could be moved, independently of the hull, over an arc of 10 degrees.

The experience of the French Army with the *Char B* did not discourage Berge nor did it prevent his proposal from being accepted for further study by the Swedish Army Ordnance. However, it clearly indicated the need to reexamine the problem of gun laying by turning a vehicle very carefully. This was first explored in the winter of 1957–58 at the Swedish Armoured Centre at Skövde using an IKV 103, a light turretless 105-mm. assault gun built by AB Landsverk and Bofors, fitted with a "crowbar" steering system.

In essence, the "crowbar" system consisted of a lever on either side of the vehicle, one end of each lever being pivoted on the hull and the other having a foot which could be made to rest on the track and move it when the lever was rotated about the pivot by a hydraulic ram mounted on a frame attached to the front of the vehicle. The "crowbar" system fitted to the IKV 103 provided a simple method of precise control over small track movement and proved that a gun could be aimed with sufficient accuracy by turning a vehicle with an appropriate steering system.

The results obtained with the IKV 103 were verified in 1959 using the chassis of a U.S. M4 Sherman medium tank. In this case the levers of the "crowbar" system were located between the tracks and the hull and the



IKV 103 assault gun with an experimental, external "crowbar" steering system.

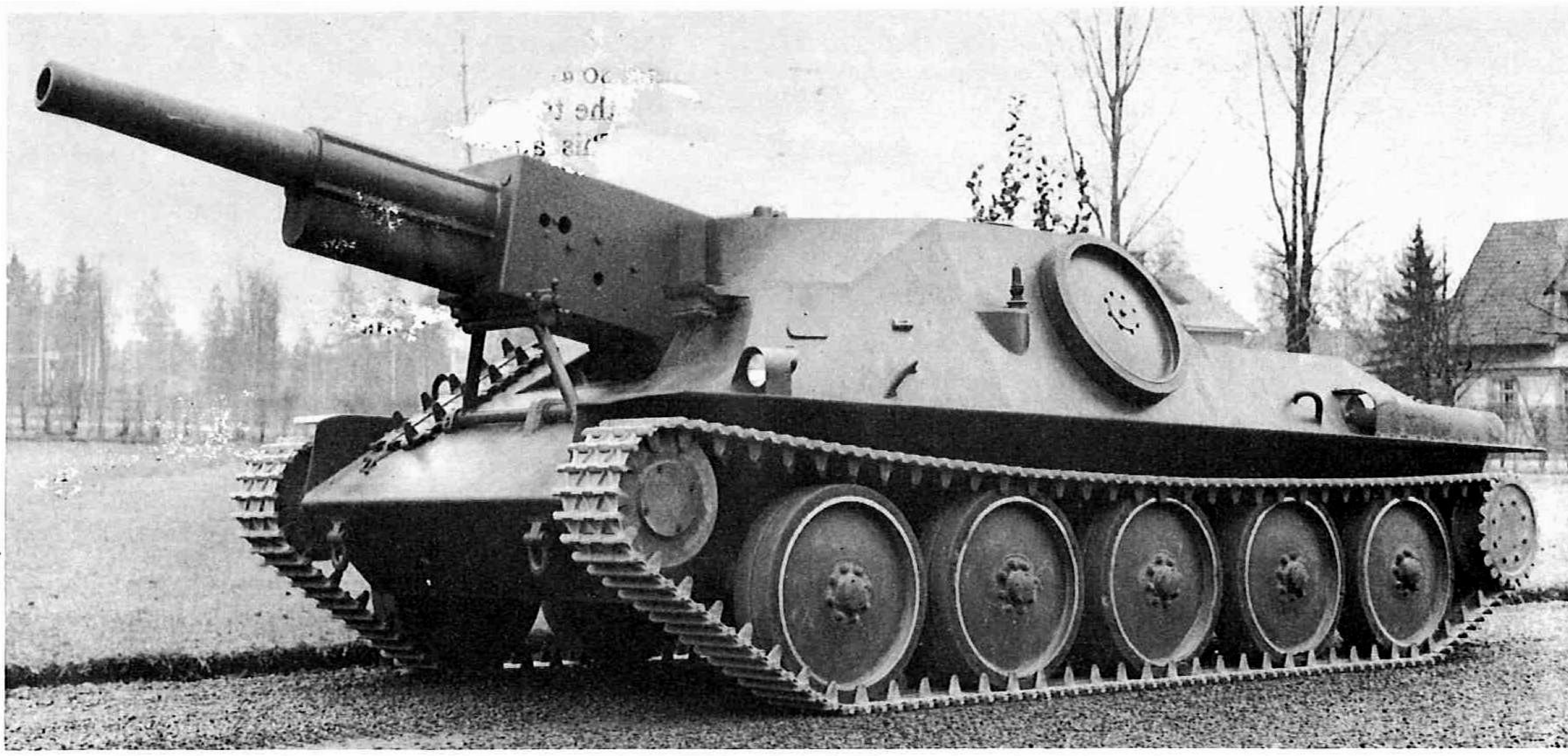
hydraulic rams were inside the hull superstructure, over the tracks, which made it all look much tidier. However, the main reason for building the second test rig was to check that there were no unforeseen scale effects between the 9-ton IKV 103 and the proposed tank which like the Sherman chassis was expected to weigh about 30 tons. The Sherman chassis was also fitted with a 150-mm. gun without recoil gear to explore the effects of rigidly mounting guns, which was originally proposed in Germany towards the end of the Second World War. The rigid mounting proved acceptable but it was not pursued further.

COMPONENT DEVELOPMENT

In the meantime, on the strength of the results obtained with the IKV 103 and paper studies, Bofors were awarded a contract in mid-1958 to develop the proposed turretless tank with a fixed gun mounting. This was to embody such novel features as an adjustable hydro-pneumatic suspension, a new steering system and an automatic loading mechanism.

Bofors had by then only designed two armoured vehicles and neither got beyond the prototype stage. One was the Lvkv 42, the 13.5-ton 40-mm. self-propelled anti-aircraft gun with an adjustable suspension built for the Swedish Army in 1954; the other was a 20-ton turretless 120-mm. assault gun with an automatic loading mechanism which was built by Bofors on their own initiative in the late forties. However, both vehicles incorporated original features which foreshadowed those of the S-tank and Bofors were well qualified to undertake its development not only because of this but even more because of their very considerable experience of naval and anti-aircraft gun control systems which was

Sherman medium tank chassis with an internal "crowbar" steering system.



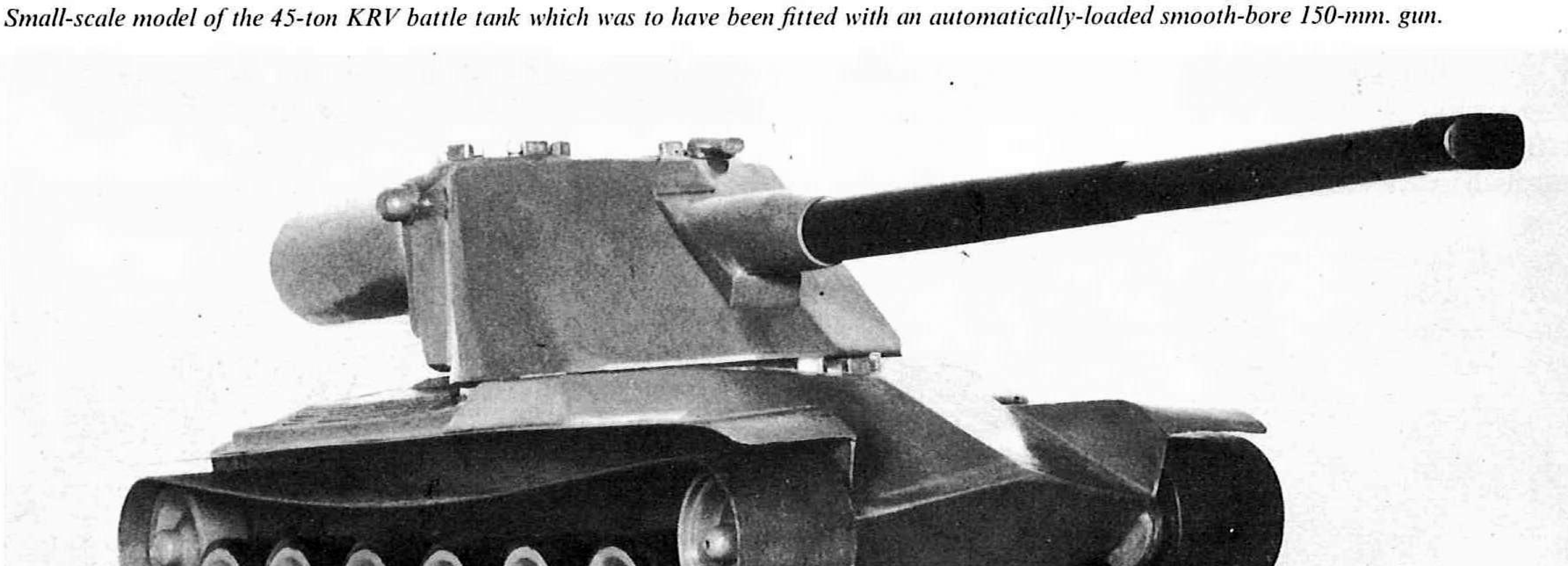
Bofors 120-mm. experimental assault gun with automatic loading.

highly relevant to a sophisticated fighting vehicle such as the S-tank.

Moreover, Bofors were assisted in the development of the S-tank by AB Volvo, Sweden's leading motor manufacturers, who were brought into it in 1959 as subcontractors for the power plant, and by AB Landsverk, who became subcontractors for much of the running gear. A little earlier, in May 1959, Bofors received an order from the Swedish Army for the construction of two prototypes.

At about the same time the Swedish Army also decided to abandon the development of an earlier, turreted battle tank, the Strv KRV, designed by AB Landsverk who had been Sweden's leading tank producers since 1930. This was a 45-ton vehicle powered by a specially developed 850 h.p. V–12 air-cooled spark ignition engine which was to have been fitted with a large Bofors-designed turret mounting a smooth-bore automatically-loaded 150-mm. gun. However the turret was never made and the two KRV tank chassis which had been built by 1957 were converted into test rigs for the S-tank components. In the process the number of road wheels was reduced from six per side to four so that in this respect, as well as in their 30-ton weight, they would resemble the S-tank. The modified chassis were then fitted with the hydro-pneumatic suspension intended for the S-tank, which was extensively tested in them during 1960, and a new steering mechanism with a hydrostatic steering drive. Finally one of them was also fitted with a high-velocity gun—the 83.4-mm. 20-pounder of the contemporary Centurions. Thus, even before the first prototype of the S-tank was completed, its basic components had been extensively tested and its general characteristics were being proved.

Small-scale model of the 45-ton KRV battle tank which was to have been fitted with an automatically-loaded smooth-bore 150-mm. gun.



SUSPENSION AND STEERING

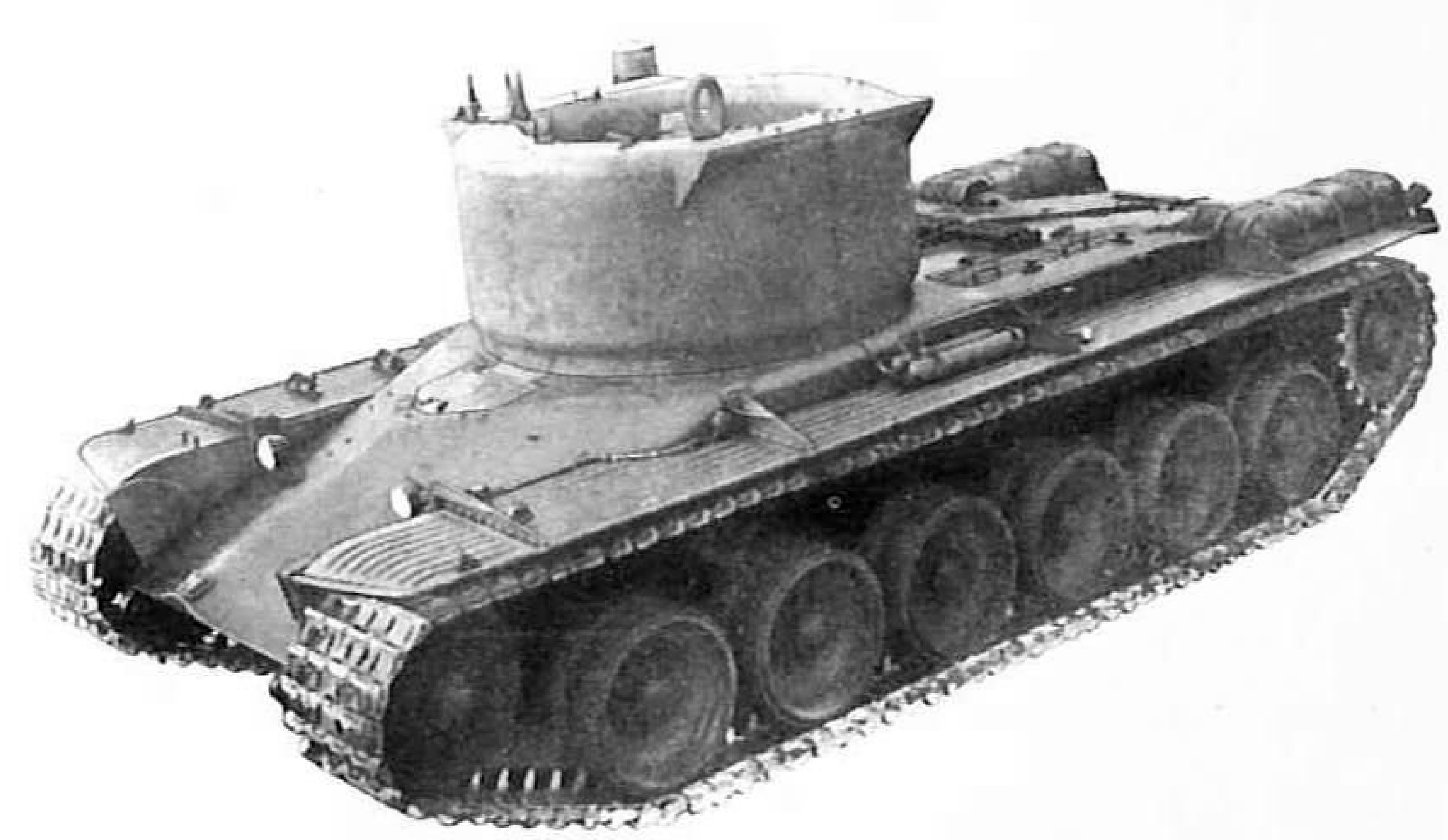
The final proof of the S-tank concept was provided by the two prototypes which were completed in 1961 and which for the first time incorporated all its essential features. The hydro-pneumatic suspension which allowed the pitch of the hull to be changed includes four road wheels per side, the front and third wheels being mounted on leading arms and the second and fourth on trailing arms. Each arm is connected to a piston in a hydraulic cylinder and this, in turn, is hydraulically connected to a second, or spring, cylinder where a floating piston separates the hydraulic fluid from the springing medium, which is nitrogen. The cylinder assemblies of the two centre wheels on each side are independent of each other and the rest of the system. But the front and rear wheel suspension units are connected diagonally across the vehicle, e.g. the front right unit is connected to the rear left unit, and each hydraulic interconnection includes a positive displacement pump which can transfer fluid from the front to the rear unit, or vice versa. This changes the pitch of the hull by altering the setting of the road wheel arms and consequently elevates the gun to a maximum of 12 degrees above the horizontal or depresses it 10 degrees below the horizontal.

Changes in the attitude of the hull inevitably involve changes in the length of the track which had to be compensated for. The usual method by mechanical control of the idler position was deemed too cumbersome and so another electro-hydraulic servo system was added to the two diagonally interconnected suspension systems. This alters the height of the hull above the ground by simultaneously adding or subtracting an equal amount of fluid from the front and rear units and thereby compensates for changes in track length.

Between each pair of cylinders there is a special valve to damp vehicle motion and there is also a hydraulic interconnection between the four front and rear units which provides the equivalent of a stable, three-point support for the hull. In addition there are cut-off valves which can isolate any of the four units should it get damaged while hull pitch control is still possible with the other three units. To make it rugged the suspension system has been made to operate at a relatively low pressure, even though this has made it somewhat less compact. The most vulnerable parts of the suspension, namely the road wheels, are the same as those of the Centurions so that they can be replaced more easily from a common stock of spares.

The second of the two major problems associated with a fixed gun mounting has been solved by a novel two-stage steering system. In essence, it consists of a double-differential mechanism with a hydrostatic steering drive and a superimposed clutch-and-brake system which comes into operation when sharp turns are

Prototype of the KRV battle tank with a cylindrical weight simulating its turret.



Chassis of the KRV modified into a test rig for the S-tank's hydro-pneumatic suspension and steering system.

Test rig based on the KRV chassis fitted with a 83.4-mm. 20-pounder of the Centurion.

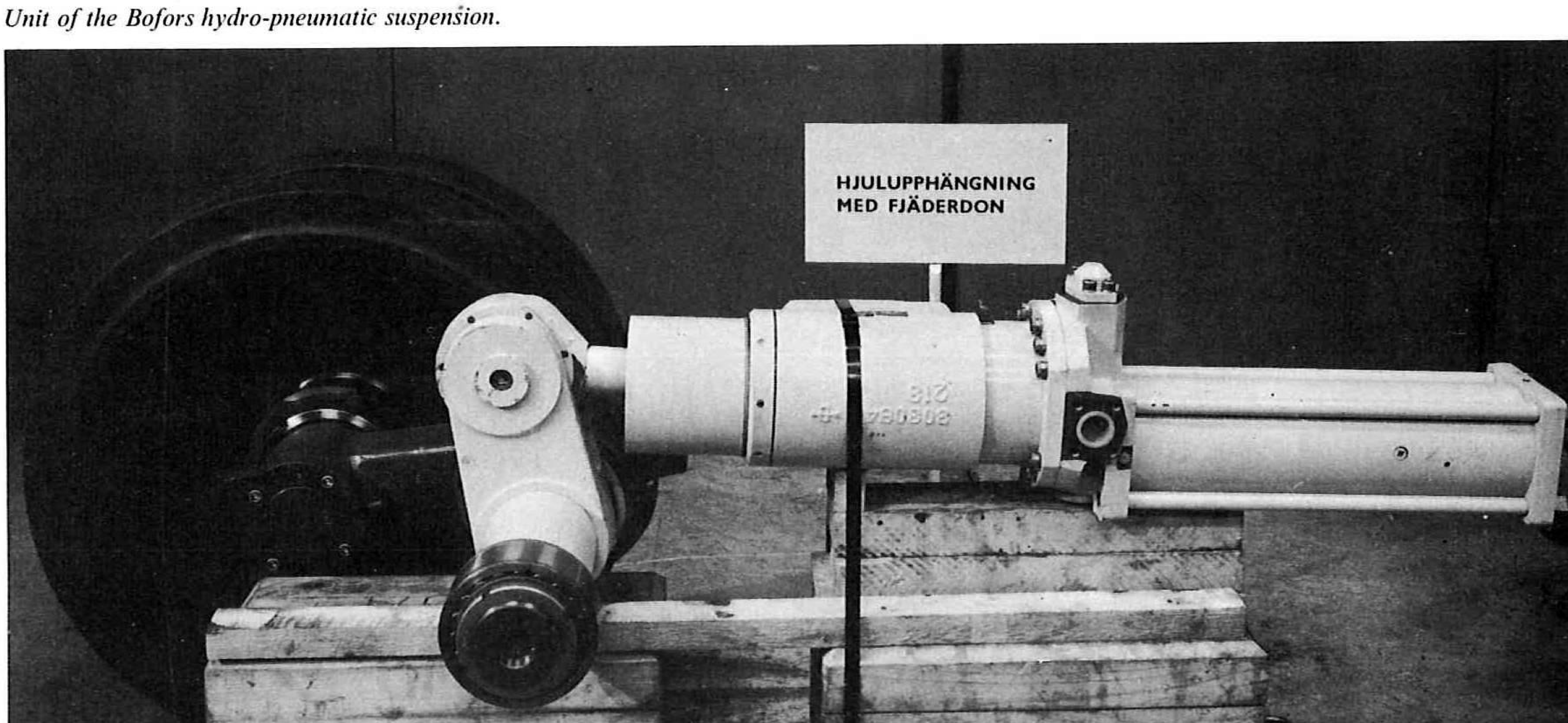
required. Thus, the steering system of the S-tank operates in two stages. In the first instance it behaves as a double-differential system, so that it is regenerative and there is no loss of vehicle speed during steering movements. At the same time the hydrostatic steering drive makes the steering infinitely variable and provides the smooth traverse control necessary for laying the gun accurately on target. In the second stage of steering, when one of the clutches is disengaged and the associated brake is applied, the steering behaves like a geared system with a large step-down. This enables the S-tank to change direction very rapidly—so much so that it can swing its gun round as quickly, or quicker, than the turret of a conventional tank.

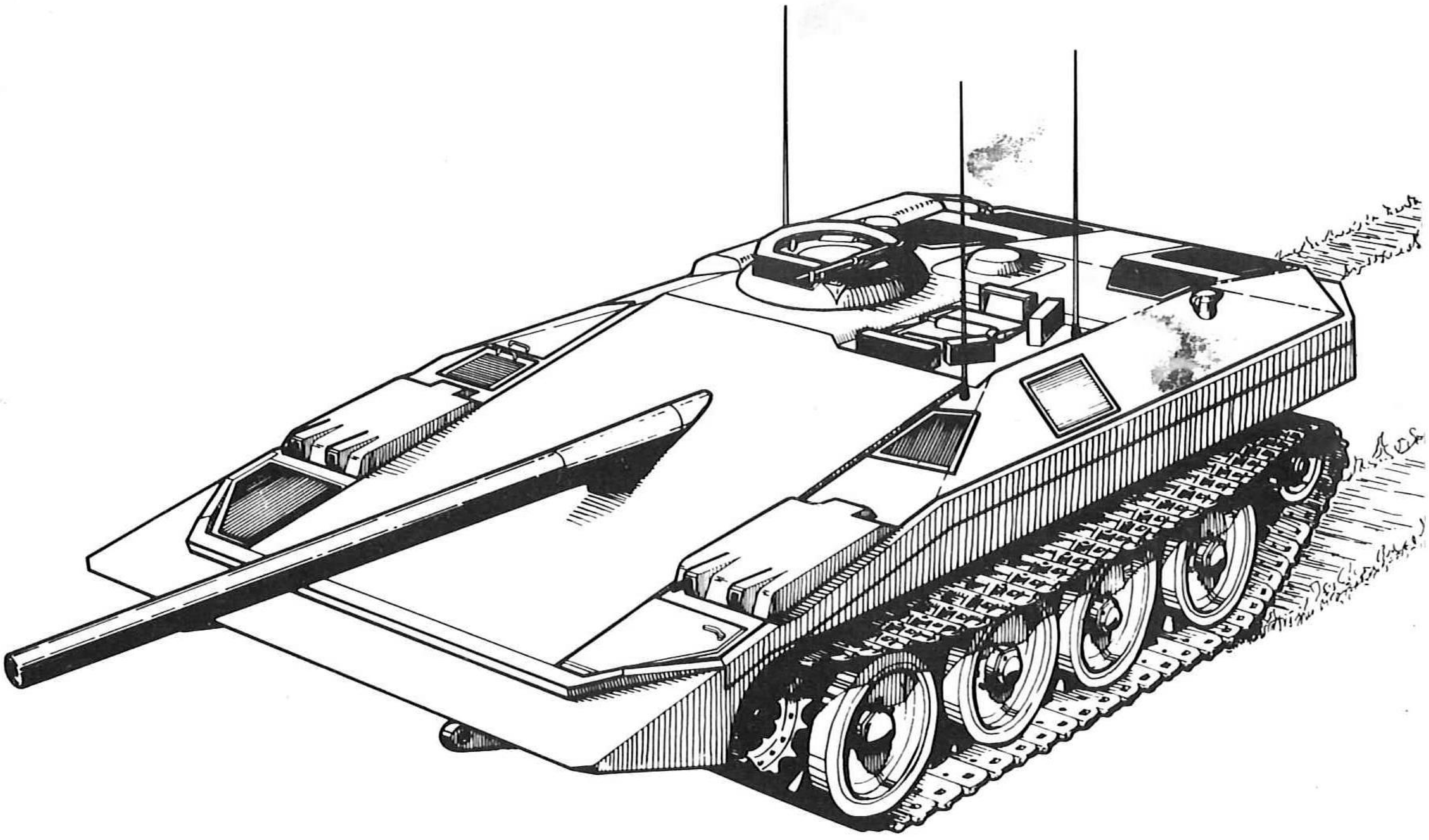
The provision of hull pitch control and of a two-stage steering system has not, for all its inevitable complexity, brought in any complication from the vehicle users' point of view. The S-tank is, in fact, simpler to operate than other tanks due to the integration of the steering and gun controls into a single unit which consists of a box with handle-bars. Rotation of the box about a vertical axis steers the vehicle: the first 23 degrees of rotation control the hydrostatic steering unit while further rotation actuates the clutch-and-brake system. Twisting the handle-bars, on the other hand, alters the pitch of the hull. In addition the control box contains a number of push buttons for loading and firing the main and auxiliary armament.

Both the driver and the commander of the S-tank are provided with such a control unit and each also has an accelerator and a brake pedal, so that either can operate the tank by himself, the commander being able to override the gunner. Normally the driver is also expected to act as the gunner but if a target is to be engaged quickly the commander, who is likely to acquire it first, can do it by himself. Thus the commander does not have to go through the usual motions of issuing orders to other crew members who then have to react to them before a target can be engaged.

The driver/gunner and the commander are located

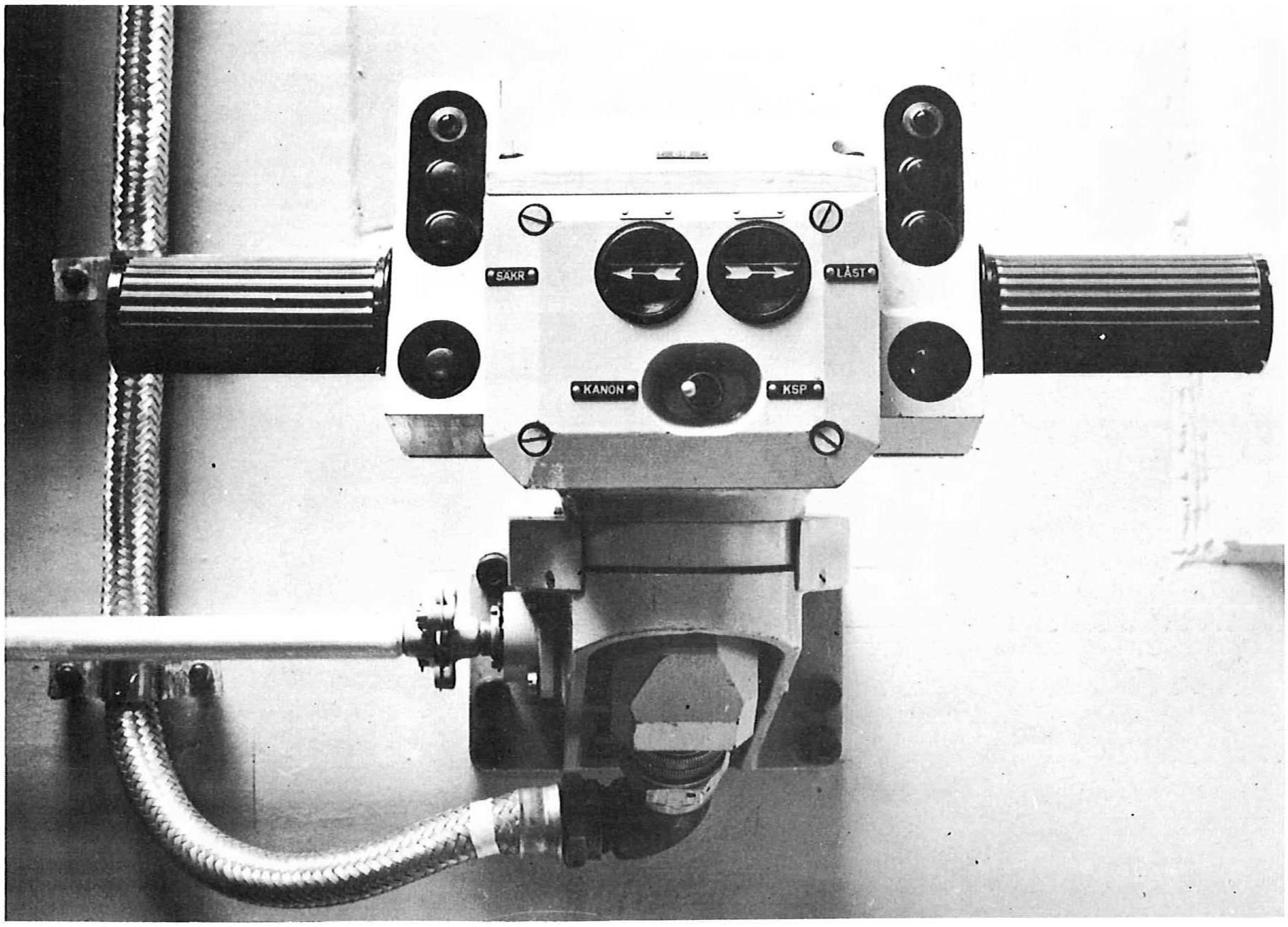
Unit of the Bofors hydro-pneumatic suspension.

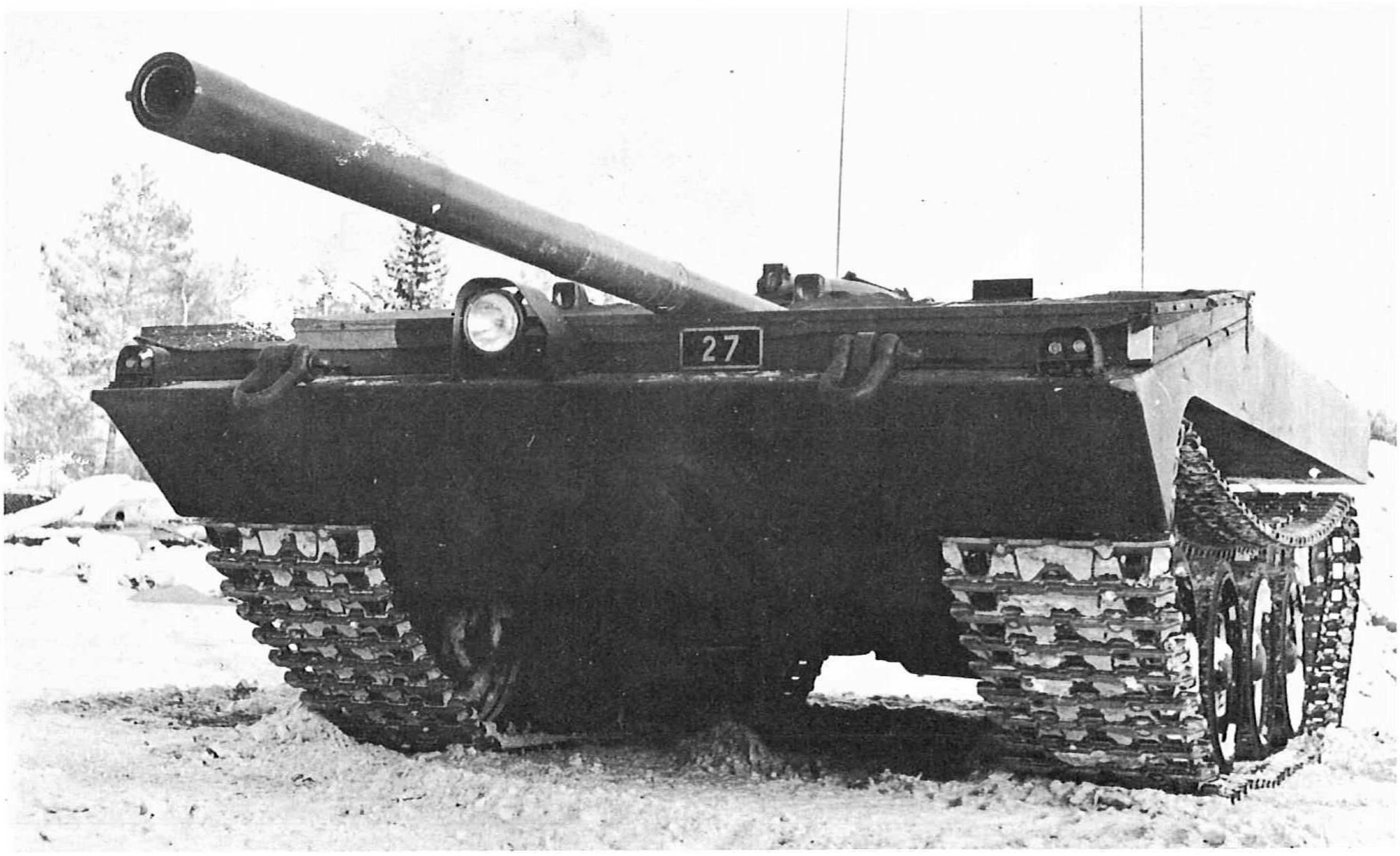




Drawing of the S-tank prototype which shows the original pair of machine-gun boxes with two 7.62-mm. machine-guns in each.

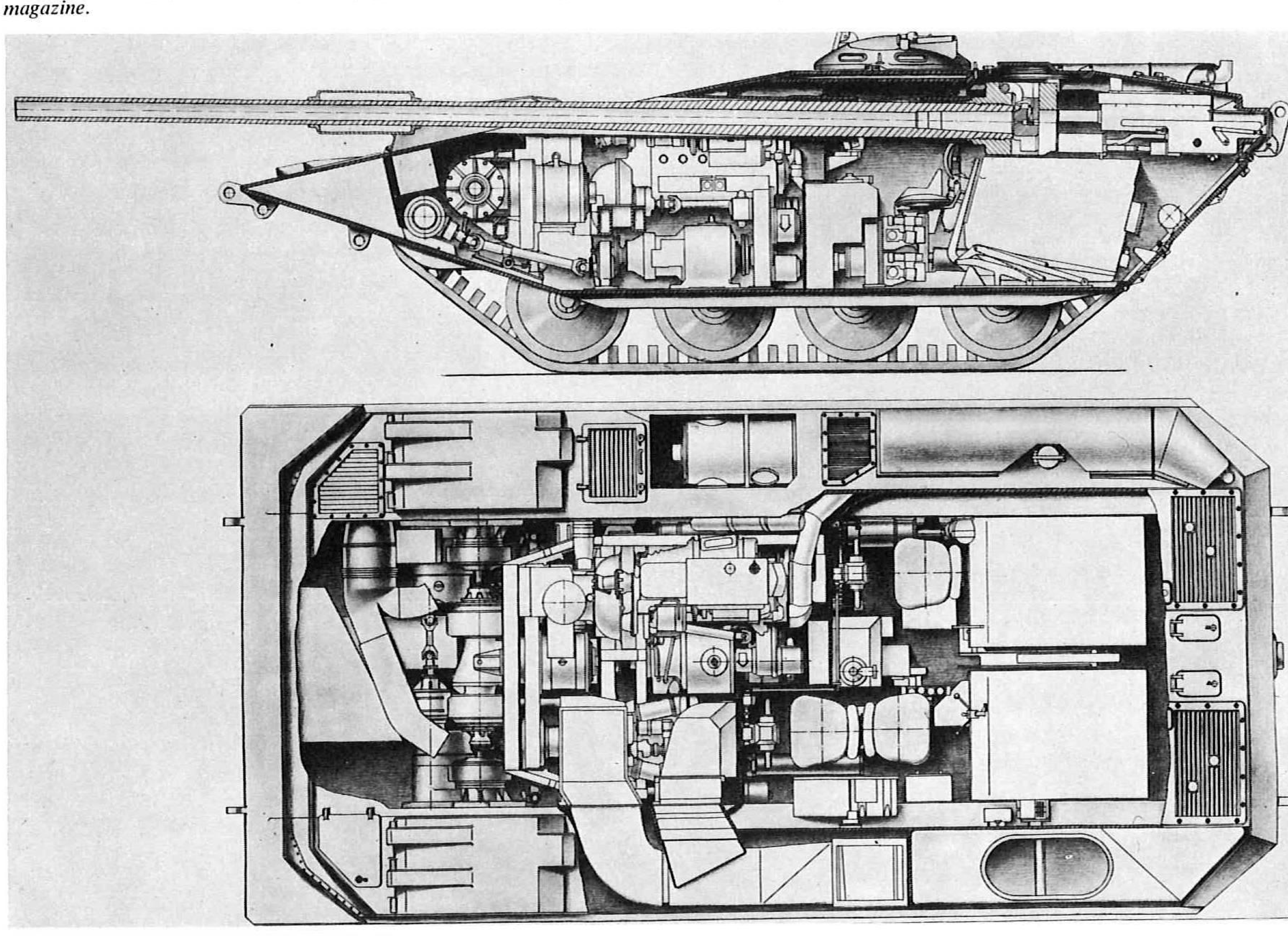
Steering and suspension control unit with loading and firing buttons for the main and auxiliary armament.

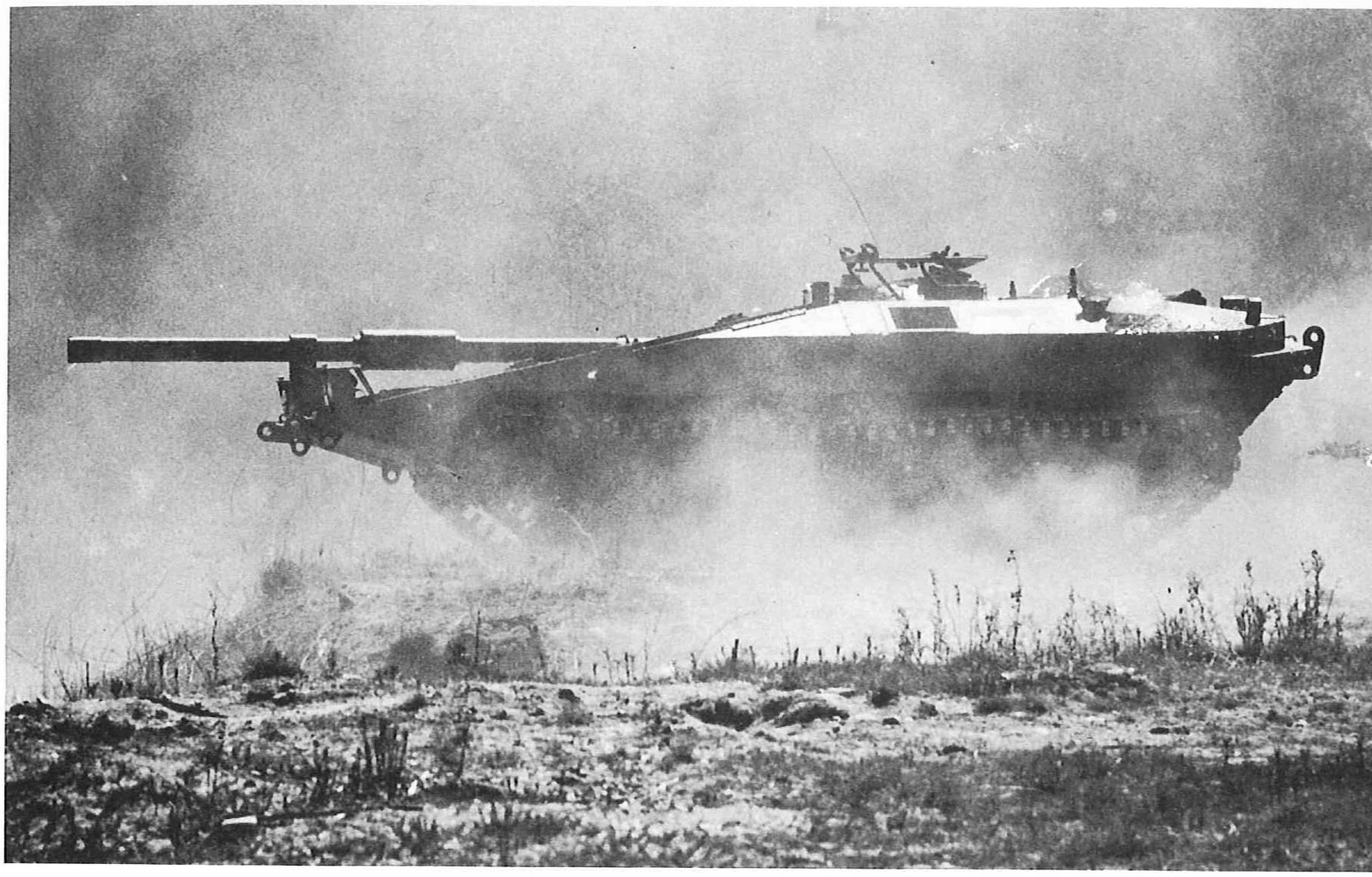




S-tank prototype with the original all-steel track.

Sectioned drawing of the S-tank in prototype form which shows the forward location of the engines and transmission and the rear location of the ammunition magazine.





Side view of S-tank pre-production model without machine-gun boxes.

abreast of each other in the centre of the tank. Behind the driver and facing rearwards is the third member of the S-tank's three-man crew—a radio operator who is also provided with a simplified set of driving controls so that he can drive the tank backwards. Its ability to be driven backwards as easily as forwards is peculiar to the S-tank and gives it a unique advantage in this respect over others. The rearward facing location of the third crewman also means that he can keep a constant watch over the rear sector of the S-tank which gives it another unique advantage over other tanks.

ARMAMENT SYSTEM

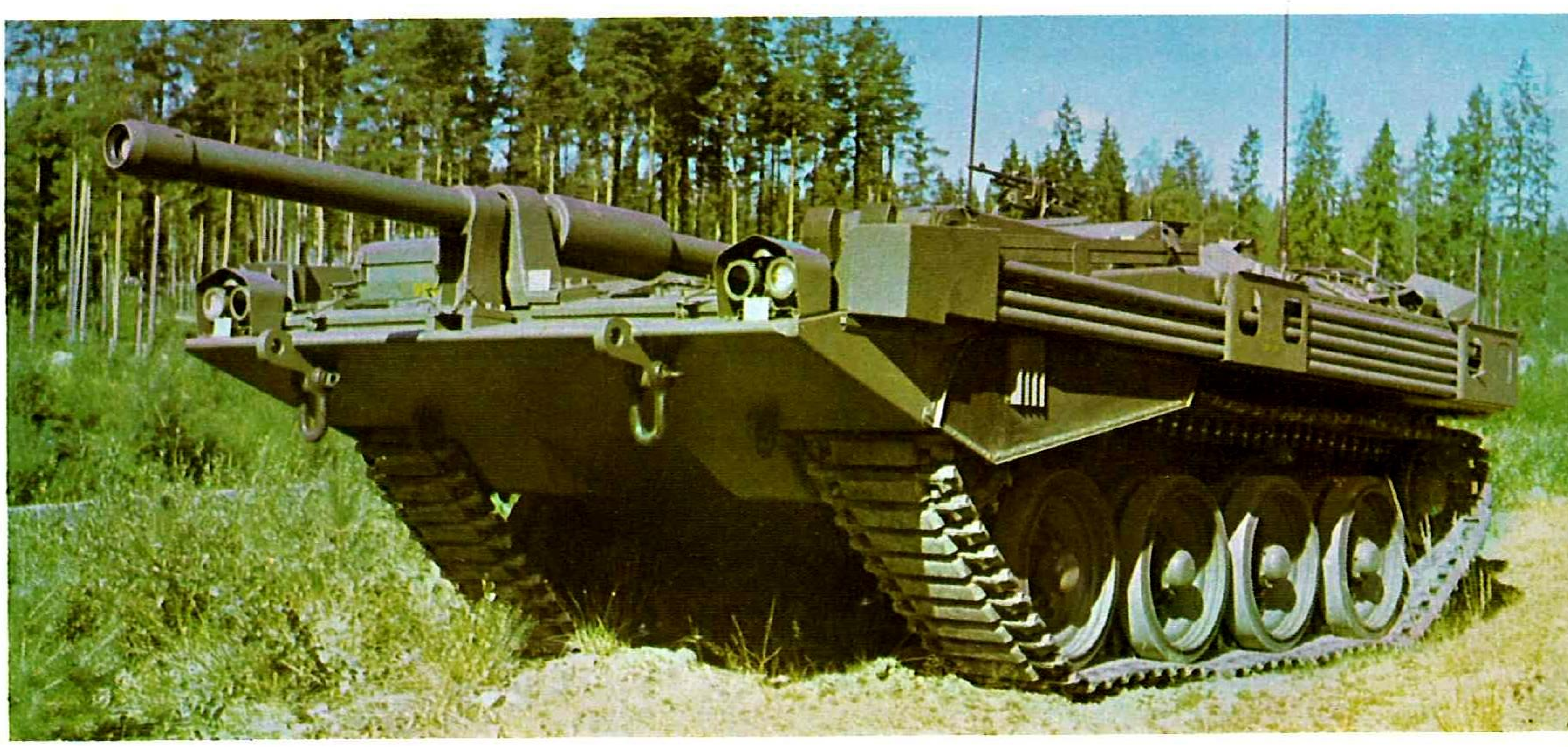
Between the driver/gunner and the commander is the S-tank's 105-mm. gun. The gun is very similar to the British L7 105-mm. gun used in several tanks, including the final versions of the Centurion, the U.S. M60, the German Leopard, the Swiss Pz.61 and the Anglo-Indian Vickers Vijayanta, and it can fire the same type of ammunition. This is particularly important to the Swedish Army as it has a considerable number of Centurions in its armoured units. However, the gun is made in Sweden by Bofors and is 62 instead of 51 calibres long, which gives its APDS projectiles a muzzle velocity significantly higher than the 1450 m/sec of the shorter barrelled gun. The higher muzzle velocity gives, in turn, greater penetration, the resulting improvement being equivalent to penetrating a typical armour plate at 500 metres longer range. At the same time the sector swept by the gun when traversed is smaller than that swept by shorter turret-mounted guns because its breech is located towards the rear of the tank.

Behind the crew compartment, at the rear of the hull, is a 50 round ammunition magazine for the gun with a hydraulically-operated automatic loading mechanism. The magazine is split into two halves on the centre line of the vehicle, one half normally containing APDS and the other HE rounds. The rounds are stowed in ten racks and descend by gravity on to a loading tray from where they are transported to the centre of the magazine area by a hydraulic ram—one to each magazine half. Once a round reaches the centre of the floor another ram lifts it to the level of the breech and a fourth pushes it home. After the round has been fired the empty case is automatically ejected through a trap door in the rear hull plate. Since there is no relative movement between the gun mounting and the ammunition magazine the whole installation is relatively simple and trouble free. The magazine is reloaded from outside through two hatches in the rear hull plate and two men can do it in approximately 10 minutes, which is considerably less than the time required to stow more conventional turreted tanks as well as being less fatiguing.

Apart from eliminating the need for a human loader, saving space and making all rounds immediately available for firing, the automatic loader of the S-tank has also increased the rate of fire to 15 rounds per minute, which is almost twice the rate of fire of tanks with manually loaded rounds of the same calibre. Its rate of fire is such in fact that the S-tank could fire its 105-mm. gun in bursts, to increase the probability of destroying a particularly dangerous target, and the possibility of doing this is increased by the automatic lock-out of the suspension whenever the gun firing button is pressed, which makes it practicable to fire successive rounds without relaying.

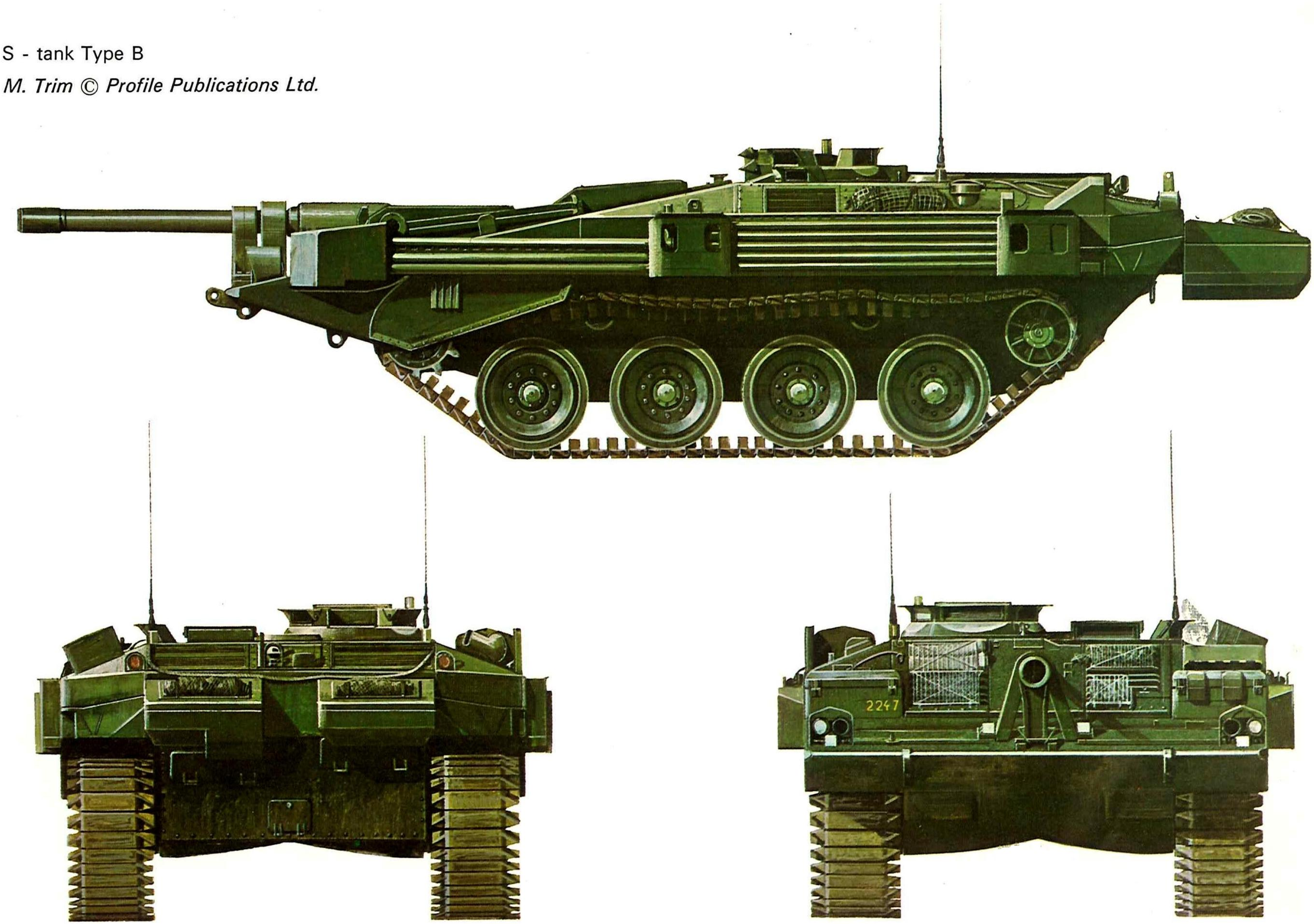
In addition to its main armament, the S-tank in the prototype form was to be fitted with four 7.62-mm. machine-guns mounted in pairs in armoured boxes on each side of the frontal hull plate. All four were to be sighted in parallel with the 105-mm. gun and fired by

S - tank Type B



S - tank Type B

M. Trim © Profile Publications Ltd.



remote control. The commander's rotating cupola was similar to that fitted at about the same time to the Pbv 301 armoured personnel carrier and like the latter was to have been fitted with an externally mounted 20mm. automatic gun. However, the mounting of the latter was considered too vulnerable for the S-tank and it was never fitted.

ENGINE INSTALLATION

As the rear of the hull was taken up by the ammunition magazine the engine and transmission compartment had to be located at the front. It contains, in fact, two different engines mounted alongside each other and geared to a common output, one engine being a diesel and the other a gas turbine.

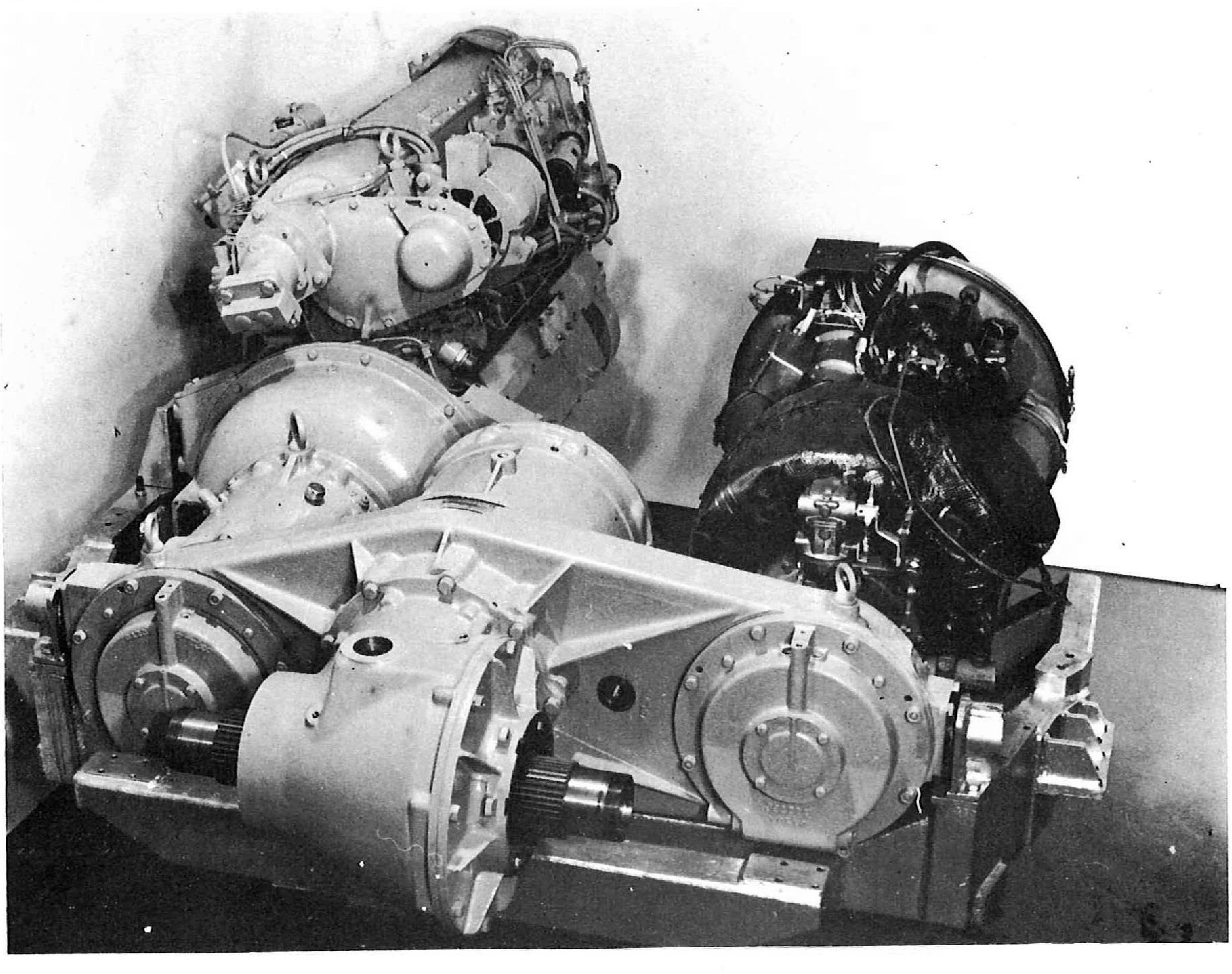
When it was adopted for the S-tank the combination of a diesel with a gas turbine had only been tried in warships. There it offered the advantage of the economy of the diesel for cruising and of being able to provide the additional power required for limited periods of time from the relatively compact gas turbine. Similar considerations led to the adoption of the combination for the S-tank. Thus the diesel was intended to be used alone under normal running conditions, when the power demand of tanks is low, and the gas turbine was to be switched on only for the relatively infrequent periods when a large amount of power is needed. Such an arrangement not only exploited the efficiency of the diesel and the high specific output of the gas turbine but also minimised the inefficiency of the latter by confining its operation to peak power periods.

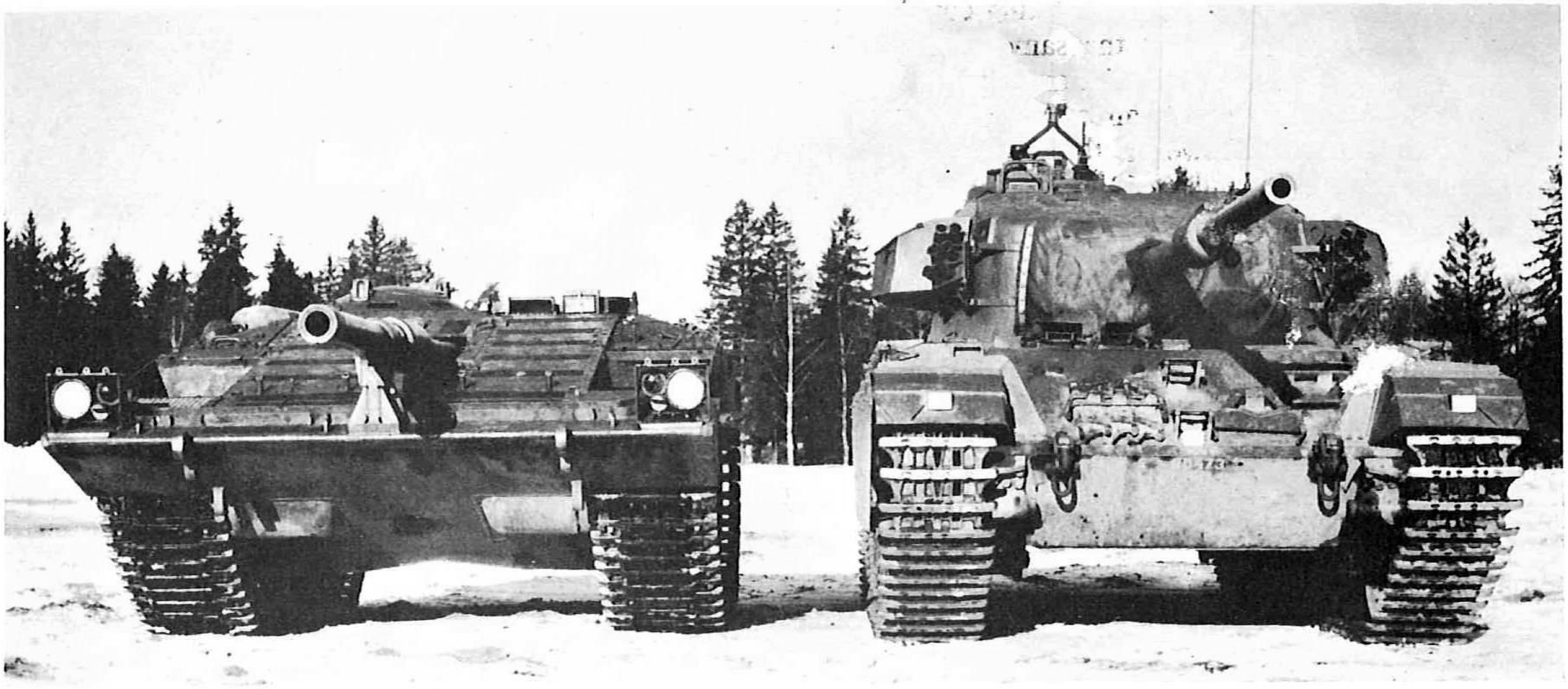
The use of the gas turbine also offered the advantage of it being easily started, particularly under cold weather conditions, and it could be used as a starter engine for the diesel when the temperature was very low—an important point under Sweden's winter conditions. The gear train coupling the two engines also allowed either to be used by itself to drive the tank in an emergency, which halved the common risk of the tank being immobilised by an engine failure.

The diesel which was actually chosen was the Rolls-Royce K–60, a 6-cylinder opposed-piston water-cooled two-stroke which had just been developed to a British Army requirement. However, the two S-tank prototypes still had to be fitted with its spark-ignition predecessor, the 8-cylinder Rolls-Royce B.81 which developed 230 b.h.p. When it became available the K-60 provided 240 b.h.p. and was coupled to a Volvo hydro-kinetic torque converter automatic transmission whose output is combined with that from the gas turbine to drive the tracks. The K-60 also drives the hydrostatic steering unit through a power take-off.

The gas turbine was the American-made Boeing 502-10MA, a simple unit without a heat exchanger and consequently relatively inefficient, but compact and proved, having been used in quantity by the U.S. Navy. It developed 330 b.h.p. but provided more power than a

Left, Rolls-Royce K.60 diesel and, right, Boeing 502–10MA gas turbine with the gear train which couples them to the output shafts.



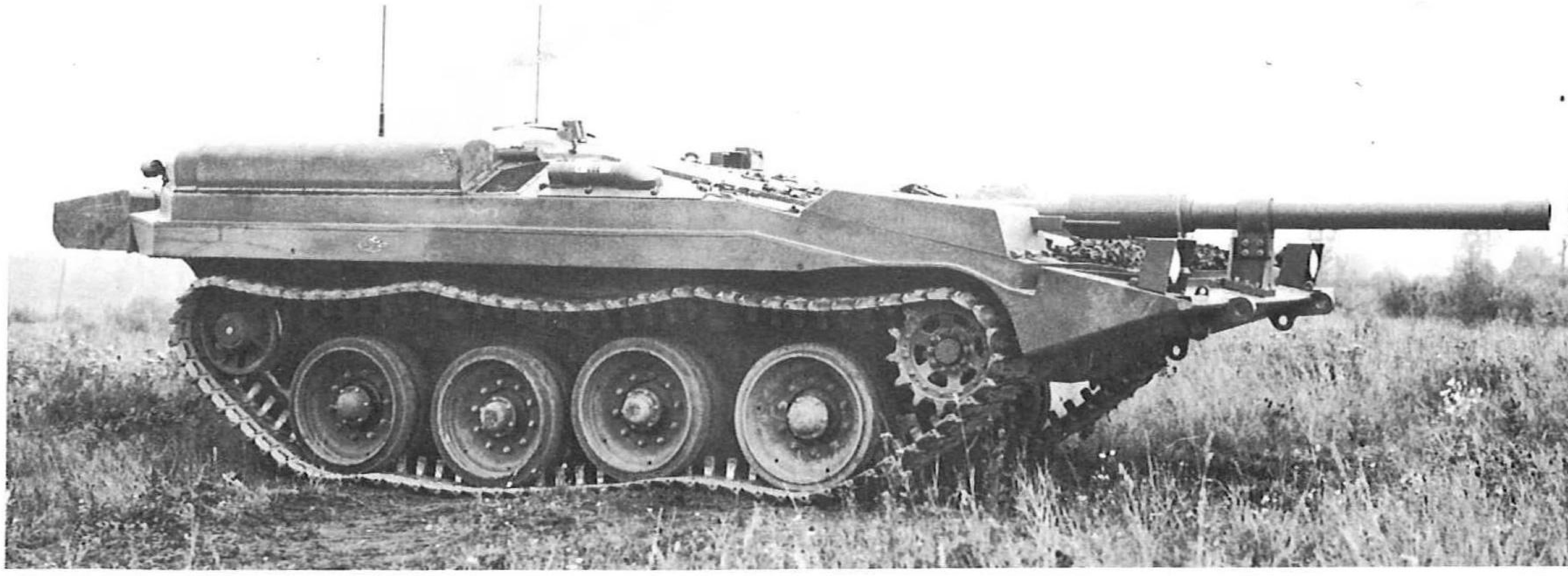


S-tank, left, compared with a conventional, turreted Centurion tank.

S-tank pre-production model with the original, domed commander's cupola.

Rear view of an S-tank pre-production model which shows the location of the radiator louvres.

Pre-production models of the S-tank during trials: note the absence of the machine-gun boxes.



Pre-production version of the S-tank with a 12.7-mm. ranging machine-gun in the right hand machine-gun box.

piston engine of the same nominal output because it did not have to drive cooling fans which consume a significant fraction of the gross horse power of piston engines.

The Boeing gas turbine was to have been replaced in time by a more efficient Volvo gas turbine with a heat exchanger but the latter did not materialize. Eventually another, more powerful Boeing model succeeded the original one and more than made up for the power which was earlier expected to come from further development of the K-60 diesel. At different times various other high output diesels were also considered, as they became available, as a possible replacement by themselves for the diesel-gas turbine combination, but none was able to provide as much power and fit in the available space.

PROBABILITY OF SURVIVAL

The location of the engine compartment at the front of the S-tank complicated access to it. In fact, provision had to be made for removing the front glacis plate which was split into three parts. Thus, a part of the frontal armour on either side of the central portion can be unbolted and swung over the centre to provide sufficient access for maintenance of the engine under it. But to replace the diesel the central portion of the plate and the gun barrel also have to be removed.

On the other hand, the location of the engines in front of the crew compartment has increased the protection against attack from the most probable direction. The main protection over the frontal arc is, of course, provided by the glacis plate which is exceptionally well sloped due to the S-tank's peculiar configuration and is therefore particularly effective against high-velocity armour-piercing projectiles. Its effectiveness has been further increased by the addition of a series of horizontal ribs, or rectangular bars, which deflect armour-piercing projectiles and thereby increase protection for less weight than the addition of conventional, solid armour plate. Ribbed armour was not, however, used on either of the prototypes as this would have revealed it prematurely.

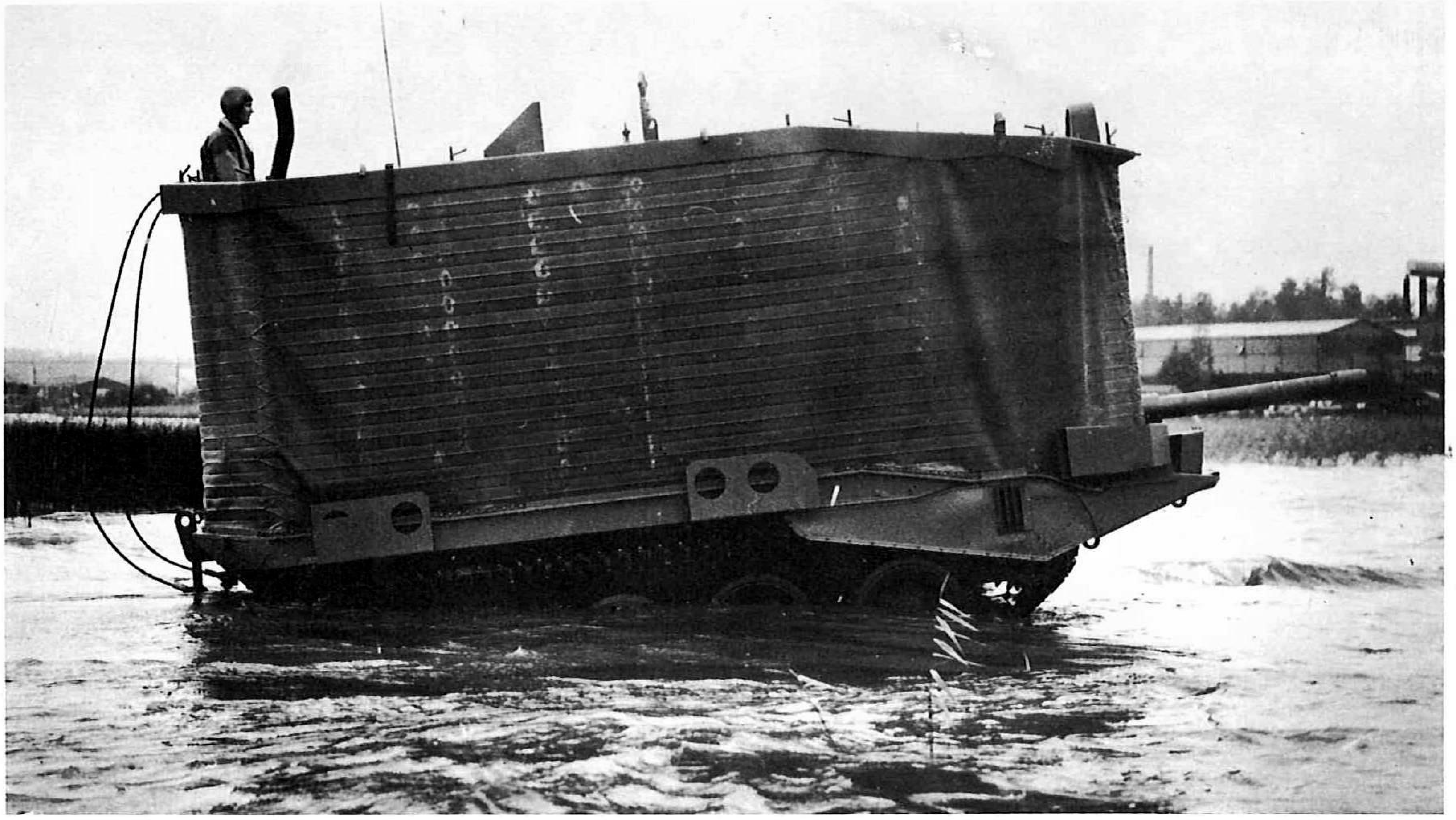
Additional protection has also been gained against attack by shaped charge projectiles or rockets by placing the main fuel tanks outside the hull above the tracks. The vulnerability of the S-tank is also reduced by the relatively low location of its gun ammunition, which is the most serious source of fires in tanks whose armour has been perforated.

The S-tank's chances of survival on a battlefield are also greatly increased by its low silhouette. Its height, measured to the top of the roof, is in fact only 1.9 metres compared with a height of at least 2.3 or 2.4 metres for turreted tanks. In consequence it presents a much more difficult target to enemy weapons and its probability of being hit is considerably reduced. For instance, when fired at in the open at 1000 metres by a typical tank gun with no sophisticated fire control equipment its probability of being hit is 12 per cent lower than that of the lowest of contemporary turreted battle tanks. Its chances of avoiding being hit are even greater than this figure would indicate because the bottom metre, or so, of any tank is usually hidden by the uneveness of the ground, which means that the percentage difference between the exposed heights of the S-tank and of a turreted tank is considerably greater than the difference between their actual heights. Thus when the bottom metre of both types is ignored the chances of a hit at 1000 metres become 34 per cent lower for the S-tank. To put it in yet another way, the probability of the S-tank being hit is only about 60 per cent that of the inevitably higher turreted tanks.

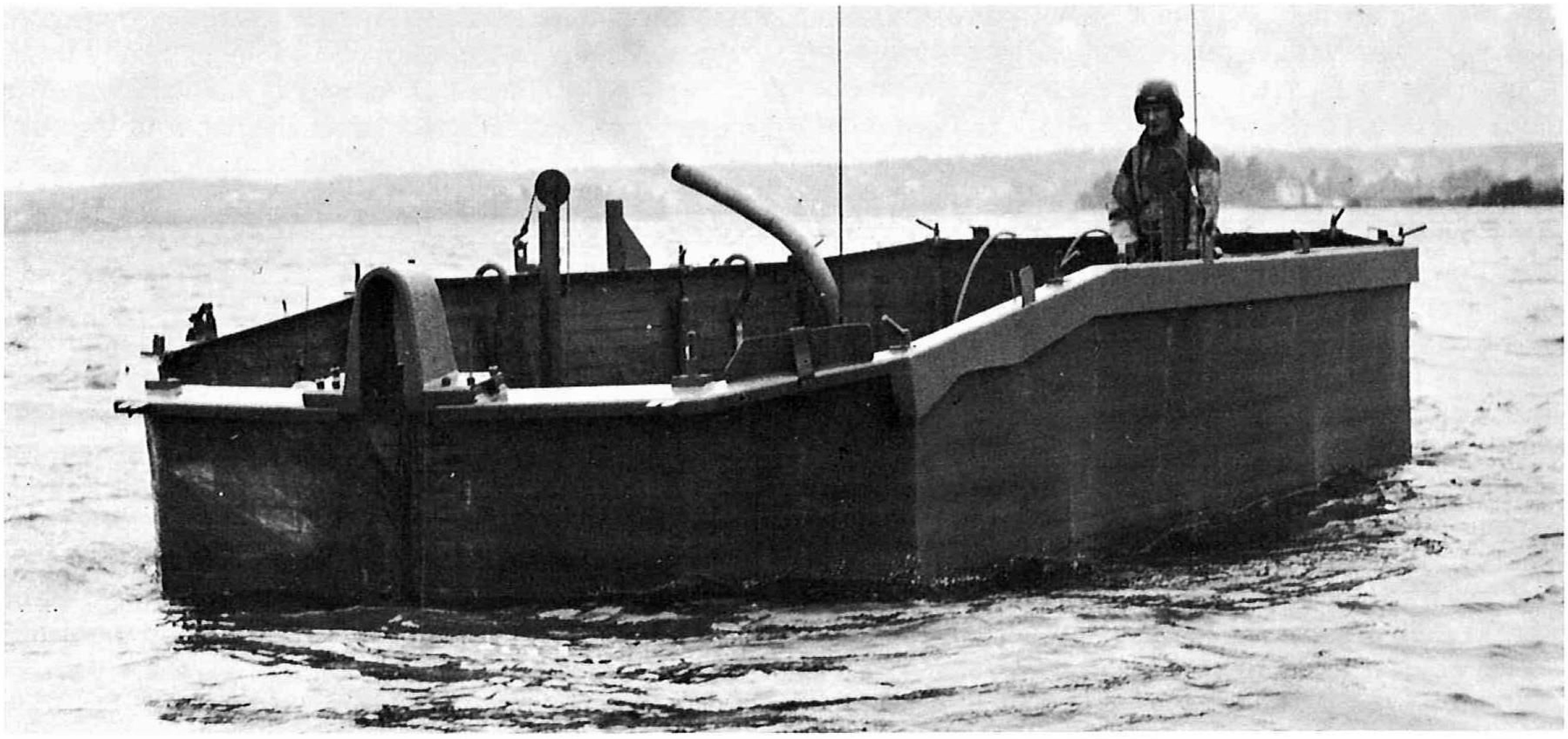
PRE-PRODUCTION VEHICLES

The various features of the S-tank were extensively tested, starting in mid-1961 with one of the two prototypes. However, even before the manufacture of the first prototype was completed, the Swedish Army became so confident of the soundness of the S-tank concept that in mid-1960 it placed an order with Bofors for a pre-production series of ten vehicles. The first of these was completed in 1963 and they were subjected to further, much more extensive trials.

As was to be expected, the pre-production vehicles incorporated a number of changes called for by the testing of the prototypes and a number of features which the S-tank was intended to have from the beginning but which were left off the prototypes. One of the most obvious changes was the addition at the front of the hull of a stout bracket to support the gun tube, particularly against bending when it accidentally hit the ground. Following similar developments elsewhere, including

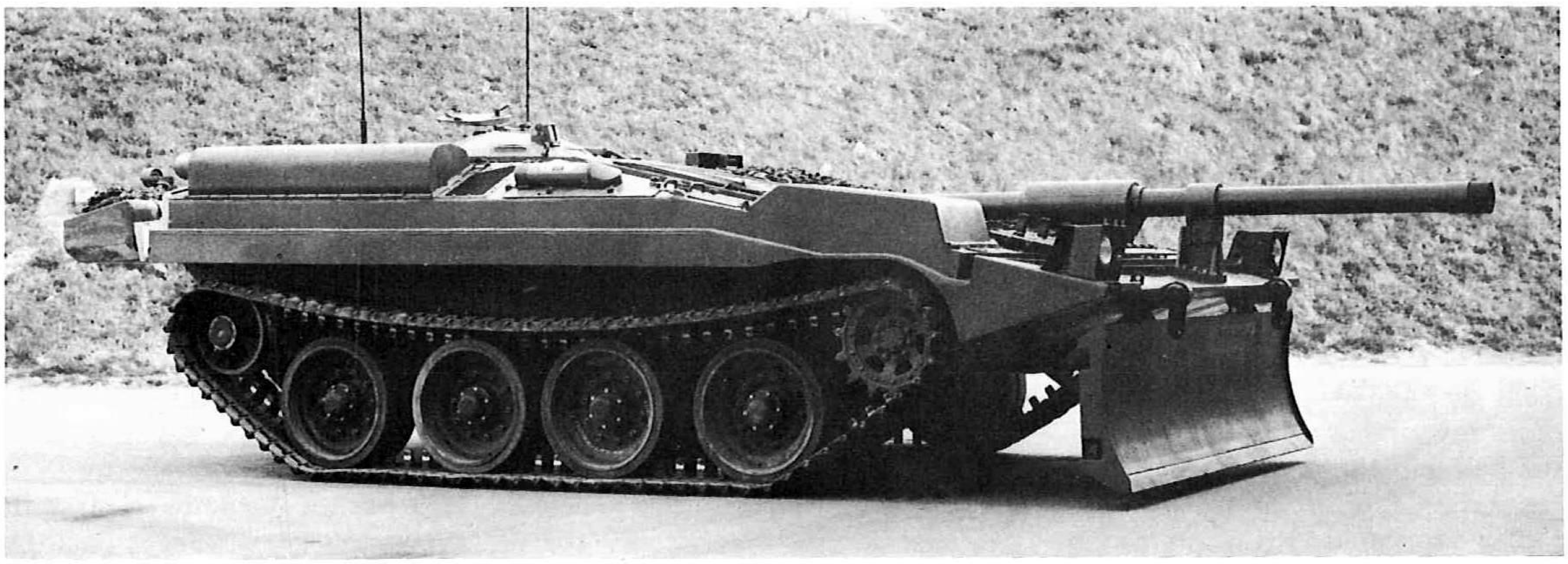


S-tank coming ashore with its flotation screen erected.



S-tank swimming with the aid of its flotation screen.

Pre-production model with the bulldozer blade locked in the working position; like the prototypes this vehicle has no track return rollers.



Beginning of the assembly of S-tanks at Bofors.

that of the British 105-mm. tank gun, the gun tube was also fitted with a fume extractor. This, together with the automatic ejection of spent cases outside the tank, virtually eliminated all chances of powder fumes entering the crew compartment.

Two return rollers were also added on each side to support the track which had previously rested on the tops of the road wheels and the track links had rubber pads bonded to them to improve road performance.

A less obvious change was the replacement of the right hand pair of 7.62-mm. machine-guns by a 12.7-mm. ranging machine-gun. The ranging machine-gun took the place of the optical range finder which was considered at first for the S-tank and which was fitted to most contemporary battle tanks, except in Britain where the 12.7-mm. ranging machine-gun was originally developed. However, the armoured boxes for the machine-guns were not fitted to all the pre-production vehicles and even when they were no weapon was generally fitted in the right-hand box because the idea of using a ranging machine-gun was abandoned by 1966.

Two other features of the S-tank which materialised only during the testing of the pre-production vehicles although they had been planned earlier were a collapsible flotation screen and a bulldozer blade. The flotation screen had been developed in Britain during the Second World War but the S-tank was the first battle tank designed to carry it permanently, neatly folded in a trough running round the upper part of the hull where it is protected from small arms bullets and shell fragments. The screen is slit at the front, to accomodate the protruding gun barrel, and when it is raised the slit is closed by means of clips. Altogether it takes the crew 15 minutes to erect the screen which enables the S-tank to float and paddle itself across inland water obstacles by means of its tracks at up to 5.5 km/hr. The propulsive effect of the tracks is increased by short shrouds fitted over their front part and the S-tank can enter or leave water at a more favourable attitude than other vehicles because the hull and the screen can be tilted by its adjustable suspension.

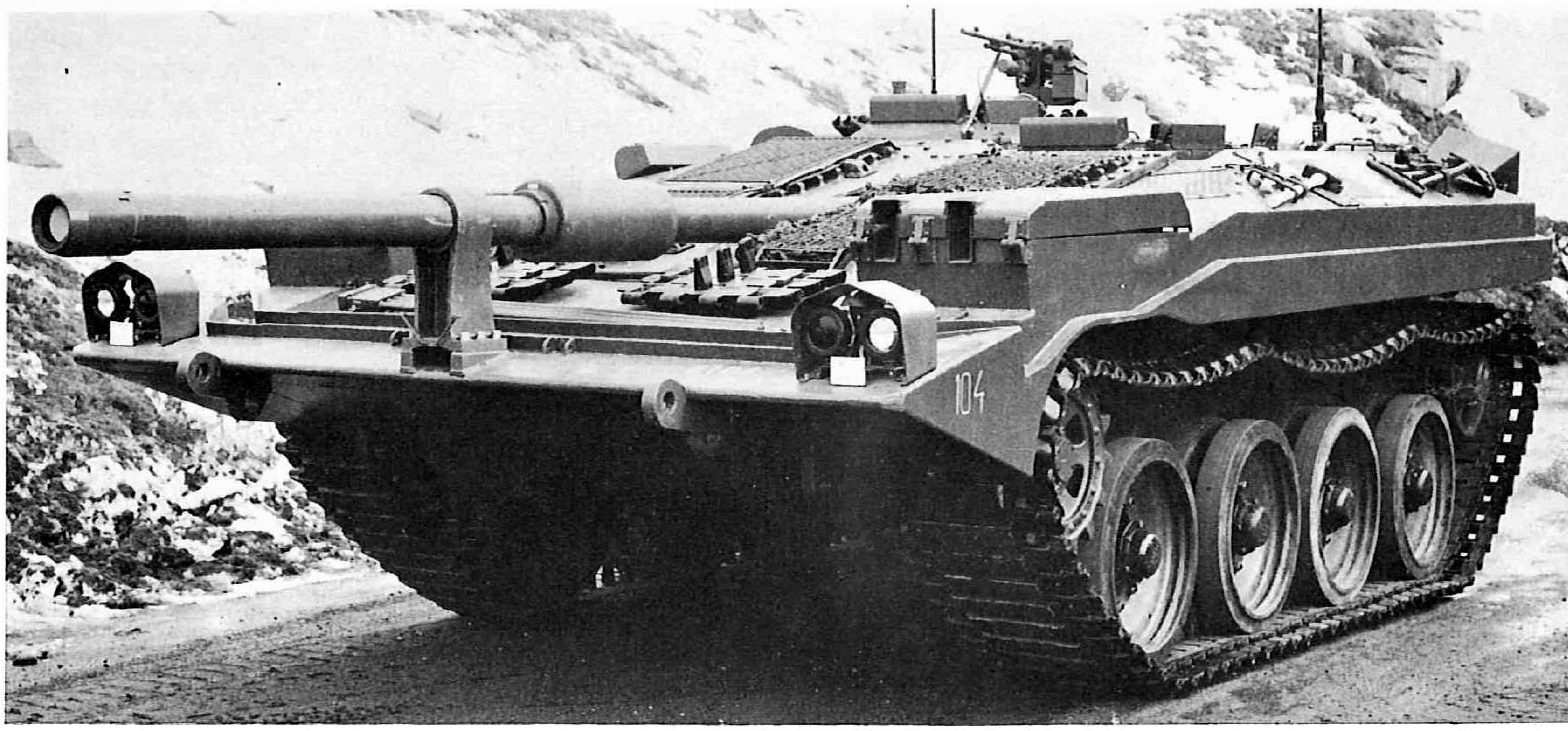
The adjustable suspension has also facilitated fitting the S-tank with a bulldozer blade with which it can dig itself in for greater protection. Normally the blade is folded under the nose of the hull but when required it only needs to be swung forward and secured by means of two pin-ended tie-rods, which is done manually by the crew in about 5 minutes. Once this is done the vertical position of the blade and hence the depth of the cut is controlled by tilting the tank's hull by means of its suspension.

PRODUCTION MODEL

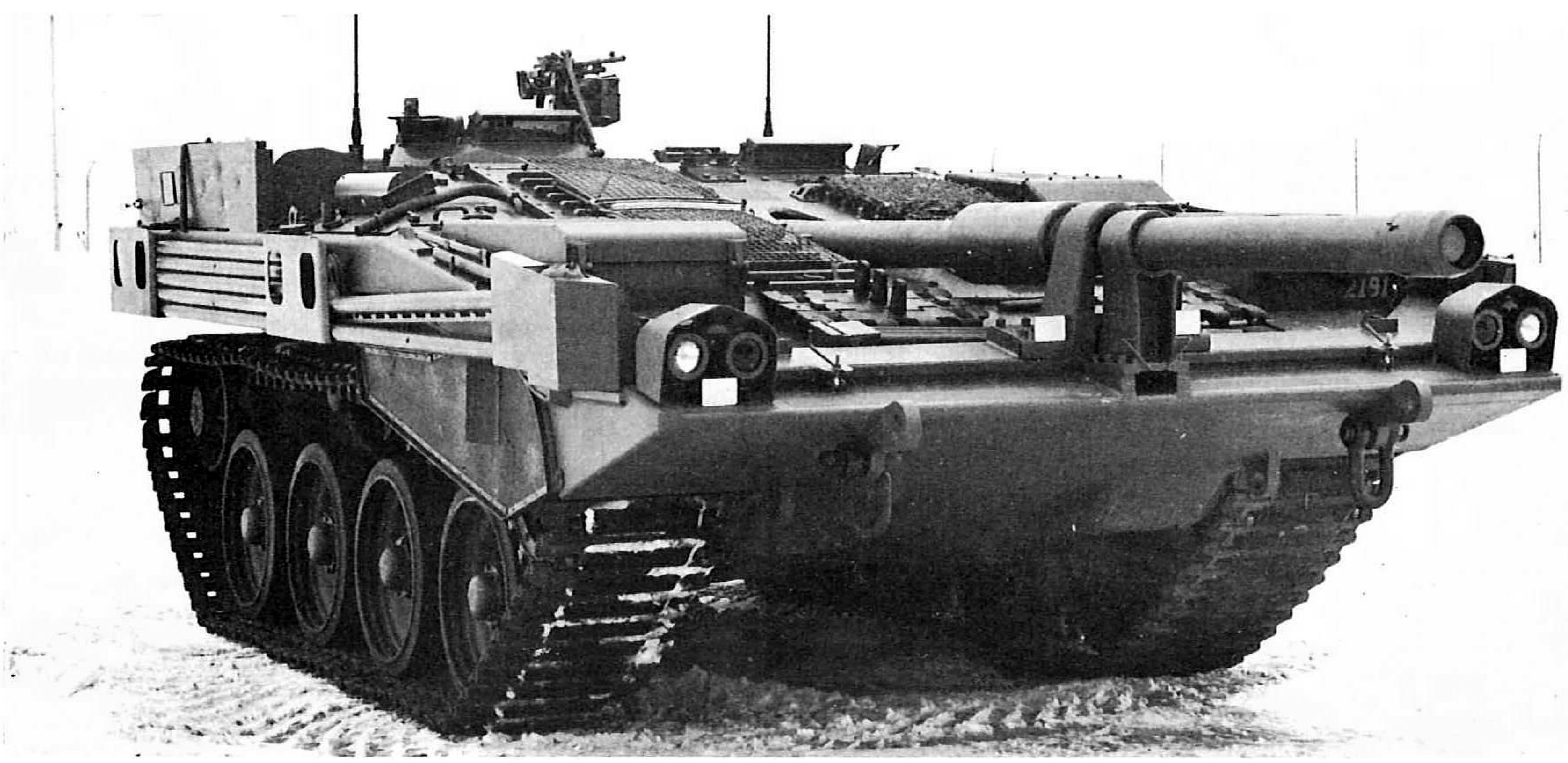
Testing of the pre-production vehicles and improving of the details of the design continued until 1967. Up to that time the cost of developing the S-tank, including the construction of the two prototypes and ten pre-production vehicles amounted to 120 million Swedish *kronor*, or £8.4 million at the contemporary rate of exchange. This meant that the development of the S-tank did not cost an undue amount and less in fact than that of several other tanks in spite of its novelty and sophistication.

In the meantime, the Swedish Army decided to adopt the S-tank for its armoured units and in July 1964 placed with Bofors a production order worth £33 million. The order began to bear fruit three years later when Bofors started to deliver the production model which they called S-tank Type A and which the Swedish Army designated Strv 103.

Externally the production models differed from the pre-production vehicles mainly in having ribbed armour, a new commander's cupola and stowage bins at the rear of the hull. However, their most interesting feature is the Jungner OPS–1 combination periscope and sight, one of which is provided for the commander and another for the driver/gunner. It consists of a unity magnification prismatic periscope with an exceptionally wide, 102 degree field of vision combined with a binocular sight whose magnification is six, ten or eighteen fold depending on the position of a small selector lever, and whose oculars are just below the bottom lens of the periscope. The driver/gunner's instrument is fixed but



Early production version of Strv 103, or S-tank Type A, without flotation equipment.



S-tank Type B with flotation equipment.

Rear view of an S-tank Type B with flotation equipment.

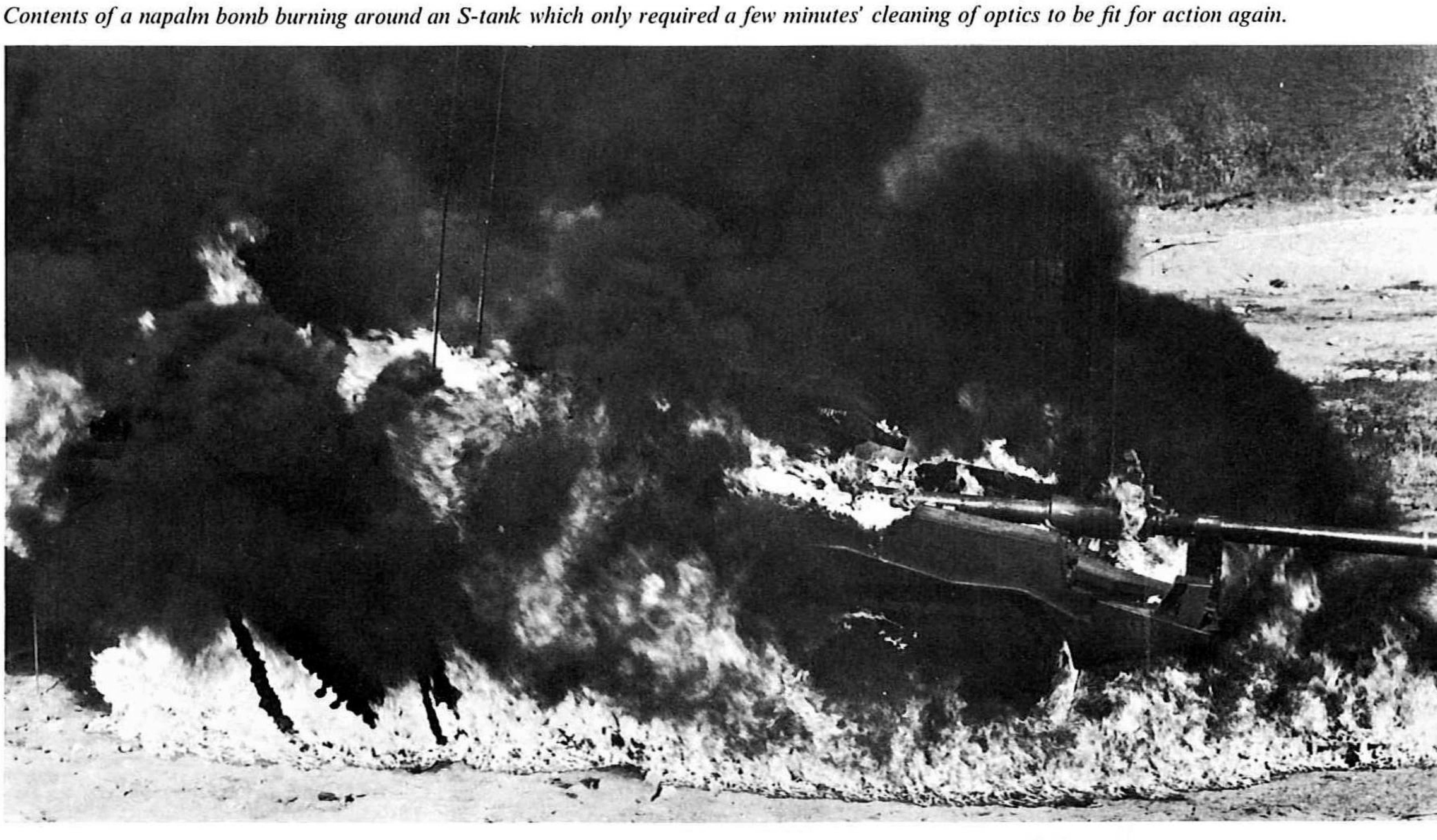
An S-tank with a mine exploding under one of its tracks during immunity trials; damage to the running gear could be repaired by the crew in about 3 hours.

the commander's is gyro-stabilised in elevation and mounted in a powered cupola which is gyro-stabilised in azimuth. In consequence the commander can observe on the move more easily that the commanders of other tanks and when he has acquired a target he can turn the tank to face it while retaining it in his sight.

On top of the commander's cupola is mounted a 7.62-mm. machine-gun which the commander can fire without exposing himself. In addition to the OPS-1 periscope/sight the commander's cupola also mounts four simple periscopes, instead of the American-type vision blocks of the original cupola, and there is also one such periscope for the driver and two for the radio operator, which gives the crew complete, all-round vision. For the first time on any tank all periscopes are fitted with armoured visors which are operated by rods from within the tank. The visors not only provide protection against accidental damage when the periscopes are not in use but also can be used to eliminate reflections from the periscope glasses which prematurely give away the position of the tank at night.

The periscope/sight has also been developed to transmit laser pulses and echoes. Experiments with a laser range-finder for the S-tank started as early as

Contents of a napalm bomb burning around an S-tank which only required a few minutes' cleaning of optics to be fit for action again.



1965 and provision for installing it, coupled to the commander's or driver/gunner's periscope/sight, has been made in the production vehicles.

The original, Type A production model was fitted with the same gas turbine as the prototypes and pre-production vehicles but the later Type B has been fitted with the more powerful Boeing 553, produced in Belgium by F.N.-Boeing S.A., which was adopted in 1966. It develops 490 b.h.p. and has improved the performance of the tank, particularly its acceleration and average road speed.

TACTICAL PERFORMANCE

Delivery of the production vehicles enabled the S-tank to be tried on an increasingly large scale by the Swedish armoured units. The trials, which have been primarily of a tactical nature, confirmed that the S-tank can carry out all but one of the roles expected of battle tanks and that it has several advantages over turreted tanks. A similar conclusion was reached in Britain where two S-tanks were evaluated in 1968.

The one thing which the S-tank can not do is to move in one direction and fire its main armament in another, as turreted tanks can. In other words, it can not engage major targets on the move, unless they happen to be at a short range straight ahead of it. This has given rise to much prejudice against it and the view, which obstinately persists in several quarters, that it is not a tank but only a limited-purpose tank destroyer.

However, all tanks have to stop to fire accurately, even when their guns are gyro-stabilised in elevation and azimuth. What really matters, therefore, is the relative speed with which the S-tank can stop and fire its gun, which depends on the overall reaction time. This is made up of a sequence of events whose duration has been significantly reduced in the S-tank or which have been entirely eliminated. In particular, because its commander and driver/gunner are both provided with a set of integrated driving and gun controls either can

Two S-tanks Type B passing through a Swedish village during winter manoeuvres.

An S-tank exposed to the shock wave of a simulated nuclear explosion.

stop the tank and fire its weapons by himself. Thus, the time which inevitably elapses in a conventional tank between the commander acquiring a target, issuing an order and the driver, gunner and loader acting on it has been eliminated. In consequence, the S-tank can react as quickly, or even quicker, than a conventional tank.

There are some occasions, of course, when the ability of the turreted tank to fire to either flank is an advantage, even though this implies having the relatively more vulnerable sides of the hull face the enemy. But in most other respects the S-tank has the advantage.

For instance, its possession of two engines reduces the chances of it being immobilised. Similarly, because the commander and driver/gunner are provided with duplicated driving and gun controls the S-tank can still be operated when either is incapacitated. In other words, in an emergency the S-tank can be effectively operated by one man. Under normal conditions the duplication of controls greatly reduces the strain on the crew. The configuration of the S-tank not only reduces the height of the target it presents but also facilitates the use of ground cover and, in particular, finding advantageous hull-down firing positions. It has also made it possible to provide its crew with a high degree of protection, in spite of the fact that at 37 tons the S-tank is one of the lightest members of the current generation of battle tanks.

The high degree of protection afforded by the S-tank was brought out particularly clearly during extensive immunity trials carried out between 1968 and 1970. During these trials S-tanks successfully survived the fire of high velocity tank guns, infantry anti-tank weapons and aircraft cannon, explosions of anti-tank mines, napalm bombs and even the blast of simulated nuclear explosions.

Acknowledgements

The writer wishes to thank Mr. S. Berge for his help in retracing the history of the S-tank and Captain K. B. Jonell for other information about it. The writer also wishes to thank the Swedish Army Materiel Department and the Bofors Company for photographs and for making it possible for him to study the S-tank at different stages of its development.

Summary of the Leading Characteristics of Strv 103 (S-tank Type B)

Gun, calibre	105-mm.
length	62 calibres
ammunition	50 rounds
Machine-guns, fixed	2 ×7.62-mm.
external	1 ×7.62-mm.
Weight, net	37000 kg
combat loaded	39000 kg
Length, with gun and stowage bins	9.8 m
without gun and bins	7.0 m
Width, overall	3.6 m
without removable fittings	3.4 m
Height, to roof over driver	1.9 m
to top of cupola	2.1 m
Ground clearance, at centre	0.5 m
at sides	0.4 m
Width of tracks	0.67 m
Track length to centre distance	1.1:1
Ground pressure	0.9 kg/cm²
Engine, diesel, make and model	Rolls-Royce K-60
gross horse power	240
gas turbine, make and model	FN-Boeing 553
gross horse power	490
Maximum road speed	50 km/hr
Range, on roads	300–400 km
Crew	3

A.F.V. Series Editor: DUNCAN CROW

AFV/Weapons Profiles

Edited by DUNCAN CROW

Starting with AFV/WEAPONS PROFILE 24 the Publishers intend to step up the frequency of publication. This departure, taken in order to meet the great demand for coverage of more AFVs more quickly than in the programme that has been running for the past two years, has necessitated some further re-arrangement in the list of titles.

29 M4 Medium (Sherman)

Perhaps the best-known and certainly the most widely produced tank in the history of armoured warfare the Sherman was first in action in October 1942, and was still on active service in the Middle East in 1971. This PROFILE gives a full account of the Sherman and its variants—apart from the Specials dealt with in *AFV/Weapons Profiles 20 and 35:* BY PETER CHAMBERLAIN AND CHRIS ELLIS, authors of *British and American Tanks of World War II* etc., and *AFV Profiles 3, 4, 7, 10, 11, 13 and AFV/Weapons Profile 20.*

30 Armoured Cars—Marmon-Herrington, Alvis-Straussler, Light Reconnaissance

The South African-built Marmon-Herringtons were familiar to all armoured car regiments in the Middle East in World War II; although only a handful of Alvis-Strausslers were used these were a significant advance in the design of wheeled fighting vehicles; the section on Light Reconnaissance Cars describes the vehicles that equipped the Reconnaissance Corps formed in 1941 to provide reconnaissance units for infantry divisions: BY B. T. WHITE, author of *British Tanks and Fighting Vehicles 1914–1945, Tanks and other Armoured Fighting Vehicles 1900–1918,* etc., *and AFV Profiles 1, 6 and AFV/Weapons Profile 21.*

31 Australian Cruiser–Sentinel; and Australian Matildas

Designed and built in Australia during World War II the Sentinel was a remarkable achievement for a limited engineering industry, and in its cast hull, for a tank of this size, it preceded the American M48 by about 10 years; it was not the Sentinel, however, that was used in action in the South-West Pacific by the Australians but the Matilda, for which they developed specialised equipments and tactics: BY MAJOR JAMES BINGHAM, *Royal Tank Regiment,* author of *AFV Profile 8 and AFV/Weapons Profile 25.*

32 M6 Heavy and M26 (Pershing)

This Profile describes the curious history of the U.S. M6 Heavy Tank and highlights the fierce controversy that raged over "giant" tanks—not only in the United States, it must be added; the M26, named after General Pershing, also started life as a heavy tank, and a few were in action in Germany in 1945. In May 1946 the Pershing's designation was changed from Heavy Tank M26 to Medium Tank M26, and as such it fought in Korea along with the M46 and M47 Mediums (Patton) that were a re-built version of it: BY COLONEL ROBERT J. ICKS, author of *AFV Profile 16* and *AFV/Weapons Profiles 24, 26,* who has a close knowledge of the tanks' development.

33 German Armoured Cars

As light tanks became popular in the 1930s the importance of armoured cars declined . . . except in Germany and France; Germany attached great importance to them and they were the basic vehicles of the Panzer divisions' reconnaissance units in World War II, achieving great success as this Profile shows: BY MAJOR-GENERAL N. W. DUNCAN, whose distinguished military career in armour has included service in armoured cars in the *Royal Tank Corps,* and command of the *30th Armoured Brigade* in *79th Armoured Division.* General Duncan has been Representative Colonel Commandant of the *Royal Tank Regiment, Governor of the Royal Hospital Chelsea,* and *Curator of the Royal Armoured Corps Tank Museum.* He is the author of *AFV Profiles 5, 9, 12, 15.*

34 Scorpion

Britain's new aluminium light tank, weighing eight tons, powered by a conventional Jaguar XK 6-cylinder engine of 4,200 c.c., and mounting a 76-mm. gun, is the first all-aluminium armoured vehicle in the world: BY R. M. OGORKIEWICZ, author of *AFV/Weapons Profile 28,* who is the first non-American and only the tenth person in its 85-year history to be made an honorary life member of the *U.S. Army Armor Association.*

35 Wheels, Tracks and Transporters British Armoured Recovery Vehicles

The problems of getting tanks to the battle and recovering them when they have been disabled are the subject of this Profile, in which MAJOR-GENERAL DUNCAN (author of *AFV Profiles 5, 9, 12, 15, and AFV/Weapons Profile 33*) traces the development in Britain of machines—some like "skyscrapers on roller skates"—to overcome the track wear bugbear until the adoption of wheeled transporters proved a better solution, and Peter Chamberlain describes the armoured recovery vehicles used by British and Commonwealth units in World War II.

36 French H35, H39 and S35

The Hotchkiss and Somua tanks equipped the *brigades de combat* of the French mechanised cavalry's *divisions légères mécaniques,* two of which had been formed before the outbreak of war in 1939, and there was a *demi-brigade* of Hotchkisses in the *divisions cuirassées;* the Hotchkiss was the second most numerous type of French tank, while the Somna was considered by many to be one of the finest AFVs of its day: BY MAJOR JAMES BINGHAM, RTR, who fought in France in 1940 when these tanks were in action.

37 Russian BT

The publishers reserve the right to alter sequence of list without notice.

Parts 1–17 price 25p each from your local book or model shop. Part 18 onwards price 35p each.
Retail prices in USA 1–17 \$1·25. 18 onwards \$1·50.

If you have any difficulty in obtaining Profiles from your local book or model shop please write direct to:

Mail Order/Subscription Department,
PROFILE PUBLICATIONS Ltd, Coburg House, Sheet Street, Windsor, Berks. SL4 1EB

Profile Warship series

The most ambitious series so far conceived and produced by *Profile Publications Limited.* This new international series will span the era of the modern fighting ship from the launching of the Dreadnought in 1906 up to the present day ship—a complex of floating electronics, weaponry and technology. *Profile* have created a team of international experts in naval history backed by a first rate group of researchers and consultants. This new series will continue to reflect the high standard of the *Profile* series already published. Presentation will follow the format which has proved so popular with the other series with first rate text, supported by many superb black and white illustrations and, of course, the famous *Profile* colour centre spread which will show complete side and plan views of each warship and where applicable additional information such as ships badges, camouflage schemes, cross sections and details of ships fittings.

The publishers intend issuing one part per month and the initial programme which at this stage is subject to revision will be as follows:

1. **HMS Dreadnought**
The first all-big-gun ship which heralded the new era that was to last for fifty years: by John Wingate, D.S.C., *Warships' Series Editor.*

2. **HMS Cossack**
Tribal Class Destroyer. The class of super-destroyers which were to serve with such distinction in World War II: by Lieutenant David Lyon, R.N.R., M.A., National Maritime Museum, Greenwich.

3. **USS Hornet (CV 8)**
Aircraft carrier who, with a life of only 372 days, launched Doolittle's raid on Tokyo before she finally paid the penalty: by Lieutenant-Commander W. H. Cracknell, USN, former observer in the US Navy Air Force.

4. **Kriegsmarine Admiral Graf Spee**
Pocket Battleship, the first class of all-welded, diesel-powered capital ships, specifically designed as commerce raiders. The Battle of the River Plate sealed her fate: by Kapitän zur See Gerhard Bidlingmaier, lately Naval Historian of the Federal German Navy, Navigating Officer of *Tirpitz* during World War II.

5. **HMS Campbeltown (USS Buchanan)**
One of the 'four-stackers' to be turned over by the USN to the RN. Her life ended gloriously during the Raid on St Nazaire in 1942: by John Wingate, D.S.C., *Warships' Series Editor.*

6. **Kriegsmarine Prinz Eugen**
Heavy Cruiser. She took part in some of the most dramatic actions of World War II: by Fregattenkapitän a.D. Paul Schmalenbach who was her Gunnery Officer and is now a naval historian.

7. **HM Motor Torpedo Boats:**
THE VOSPER 70ft BOAT
This class of boat formed the backbone of Coastal Forces' Motor Torpedo Boats during World War II. The development of the boat, the resultant tactics and strategy and the action reports are described by the author, David Cobb, R.O.I., R.S.M.A., the marine artist, who was himself a Commanding Officer and MTB Controller.

8. **Kriegsmarine U-107**
The life history of a German World War II submarine, described in detail by the world's leading authority on U-boat warfare, Dr. Jürgen Rohwer, Head of Modern Historical Section, Bibliothek für Zeitgeschichte, Stuttgart.

9. **USS Charles Ausburne**
DD 570, Fletcher Class destroyer, of Admiral Arleigh (31-knot) Burke's famous Squadron. This fighting destroyer saw operational service from World War II until the Vietnam War: by Lieutenant-Commander W. H. Cracknell, USN, author of *Warship Profile Hornet.*

10. **HMS Illustrious**
Aircraft Carrier, 1939–1942. The history of this ship will appear as two Profiles during the same month: From design stage to her major refit in America. This phase includes her attack on Taranto (the first carrier-borne attack in history, to be copied later by the Japanese at Pearl Harbour) and her terrible punishment suffered off Malta at the hands of the Luftwaffe: by Lieutenant David Lyon, R.N.R., M.A., author of *Warship Profile Cossack.*

11. **HMS Illustrious**
Aircraft Carrier, 1942–1946. Following the US refit, through the Madagascar landings to her final recall after her active service in the Pacific theatre of war: by J. D. Brown, a former Royal Naval aviator, author of *Aircraft Profile 224, Supermarine, Walrus and Seagull variants* and 'Carrier Operations of World War Two'.

12. **IJN Kongo**
Battleship. This ship, the world's largest warship of the time, saw continuous action until she was finally sunk in April 1945: by a Japanese author yet to be commissioned.

13. **HMS Exeter**
8-inch-gun Cruiser, 1928–1942. Her life includes the *Battle of the River Plate* against *Admiral Graf Spee* (*Warship Profile No. 4*) and the *Battle of the Java Sea*: by Robin Tonks, M.A., Assistant Director of Studies and Head of History Department, Britannia Royal Naval College, Dartmouth.

Available from your local book or model shop at 50p (10s.) U.S. retail price $2

Profile Publications Limited, Coburg House, Sheet Street, Windsor, Berks. SL4 1EB
Also published by Profile Publications Limited are the world-renowned Aircraft, Car and AFV series.
For further information please ask at your local book or model shop, or write direct to the publishers.

Printed in England by Edwin Snell & Sons *printers* Yeovil. May 1971