VICKERS

VIGILANT

VICKERS-ARMSTRONGS (AIRCRAFT) LIMITED GUIDED WEAPONS DIVISION

A COMPANY OF BRITISH AIRCRAFT CORPORATION

The Vickers Vigilant was designed and developed by

VICKERS-ARMSTRONGS (AIRCRAFT) LIMITED

A COMPANY OF BRITISH AIRCRAFT CORPORATION

VICKERS
VIGILANT
ANTI-TANK GUIDED WEAPON

This booklet examines the general requirements of anti-tank missiles and gives a detailed description of Vigilant. Recent successes of Vigilant at military and press demonstrations are analysed together with the technical and economic advantages which make this weapon system the world leader in its class.

REQUIREMENTS OF THE INFANTRY ANTI-TANK MISSILE

Until now the infantryman has not had a satisfactory front-line anti-tank weapon which can be brought into action quickly against targets at any range between 200 yards and a mile; the clear need has been for a rifle-ready weapon which could be carried by one man in the first wave of attack and which could kill any enemy armour.

Developments in the guided missile field have made such a weapon possible, and Vigilant has now emerged as a missile which fills all the above requirements.

Early attempts to solve the anti-tank missile problem were based on derivatives of World War II wire controlled air-to-air weapons. Crude control systems have, however, now been superseded in order to obtain simpler and cheaper training and to give much higher chances of hit and kill.

A natural and instinctive control system is the first essential to give consistent accuracy, ease of training and low peacetime maintenance costs. An autopilot is basic in such a sophisticated system, and the guidance of Vigilant is based on auto-pilot control.

Hand-in-Hand with the guidance system are needed powerful aerodynamic controls, particularly for attacking short range targets. The effective infantry anti-tank missile must have a small turning radius and also be responsive to sudden guidance commands.

A high speed is also essential to take advantage of tank sightings of only 10 or 5 seconds at long ranges. At short ranges, adequate manoeuvrability is needed to bring the missile rapidly on to course.

Many other features are desirable, such as lack of smoke and freedom from detection by the target; a control system which is not susceptible to jamming or interference; a design which is easily adaptable for commando, paratroop or vehicle application; ruggedness; reliability, etc.

Vigilant has been shown to embody all the above requirements—portability, accuracy, ease of handling, speed into action, manoeuvrability, and overall cheapness in terms of both training and of cost-per-kill.

There are two basic control systems in use in modern anti-tank missiles and, indeed, in certain air-to-ground missiles. There is often misunderstanding of the principles of each system and an opportunity is taken in this brochure to explain *velocity* and *acceleration* systems in simple language, together with their respective advantages.

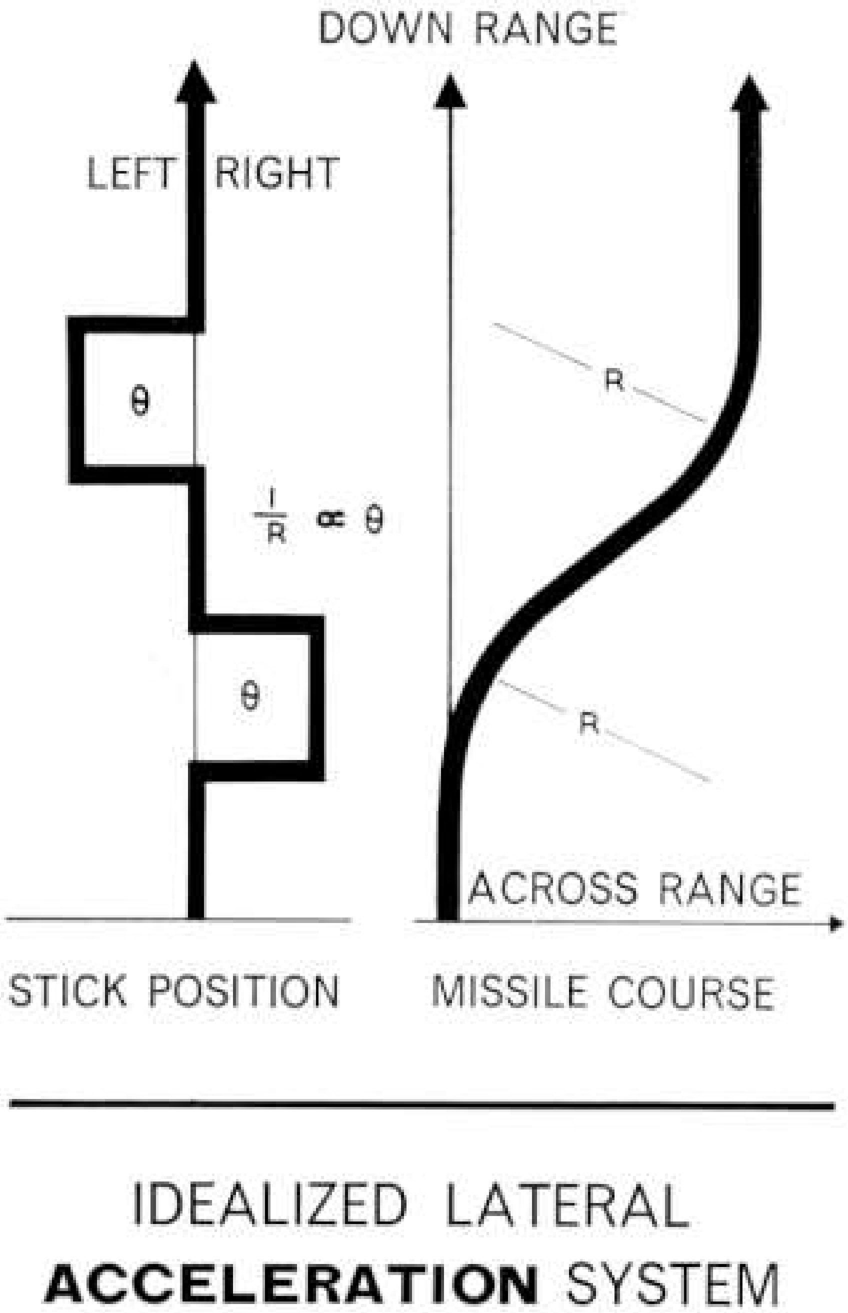


Fig. 1

ACCELERATION CONTROL

The most common and technically simple system is acceleration control which has a direct link between the operator's control stick position and the angle of the missile control surfaces. Thus, if the operator commands a turn to the right, the missile will continue travelling to the right in a circular path until the control is returned to its neutral position when the missile will fly straight along its new direction. While the control is held over to the right or left, the operator sees an *acceleration* of the missile across his sightline. He is viewing a curved flight path from a fixed position.

Reference to Fig. 1 shows that to change the displacement of the missile, say to bring it on to the operator's sightline, four separate control movements are necessary. Moreover, much and continual practice is needed to blend the radius of the flight path on to the required missile course.

VELOCITY CONTROL

The simplest system for an operator to control is one which has an autopilot as a basic component. An autopilot is as near as it is possible to get to having a man in the missile steering it on to the target. In this system a control movement to the right will turn the missile on to a new heading, after which it will fly on a straight line. When the controller is returned to the neutral position, the missile will turn again and fly in its original direction.

When a control demand is applied by the operator he sees a constant *velocity* across his sightline.

Fig. 2 shows the same problem as Fig. 1, i.e. commanding a missile displacement to the right. Only two control movements are now needed. The operator's task of guiding the missile on to the sightline is much simplified as a return to neutral position of his controller immediately restores the missile on to the required heading, the necessary correction having been achieved.

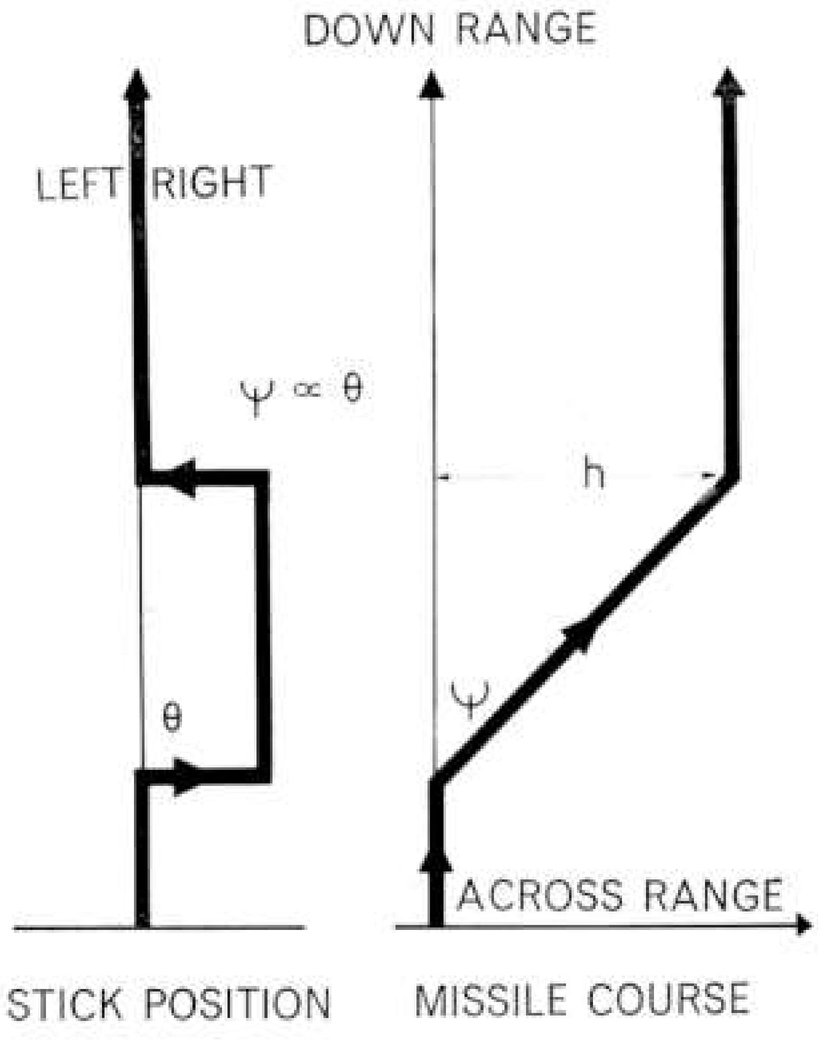
Idealized acceleration and velocity control systems cannot be achieved in practice due to the time lag involved in control and aerodynamic response. However, they can be closely approached. The incorporation of a phase advance in the electronics of the control system can give speedy control response and large control surfaces give a rapid aerodynamic response.

The velocity control system's great advantage stems from its use of an autopilot to resolve the problems of control demand and the missile's direction in space.

The resultant " natural " control system with its high accuracy easily outweighs the extra cost of manufacture.

Most people find it comparatively simple to steer a car through gateposts. This is, in fact, a velocity control system as a constant velocity of horizon is seen with a fixed steering wheel position. The task of steering a remotely controlled model car through, say, chairlegs, is much more difficult as the operator is not sitting inside the car. This is an acceleration control system.

These analogies apply directly to missile systems—the broad principles being the same.



IDEALIZED LATERAL **VELOCITY** SYSTEM

Fig. 2


A TK

VIGILANT

Vigilant was designed primarily as an infantry weapon. In particular it was designed to be a weapon that would need no selection of operators and could be carried into the battlefield and operated within seconds by just one man.

The total system weight of under 50 lbs. represents a modest shoulder load. No dependence is placed on having a vehicle to carry testing equipment or power supplies. Vigilant is instantly ready without any field-testing—it can be set up and launched within 20 seconds of the command.

The operator's guidance task is simplified by incorporating a two-axis autopilot in the control system. This makes the guidance task easier, and provides automatic levelling off after launch while giving directional stability in gusty conditions. Six recent trainees all hit moving tank targets with their first missiles after simulator training only.

Guidance commands are generated by natural thumb movements in a universally pivoted cup on the hand-held sight/controller. Such movements feed electrical signals along a multi-core wire fed out from the rear of the missile into the autopilot circuit. Besides being a basically simple method of feeding signals to the missile, a wire link is reliable and makes counter-measures practically impossible.

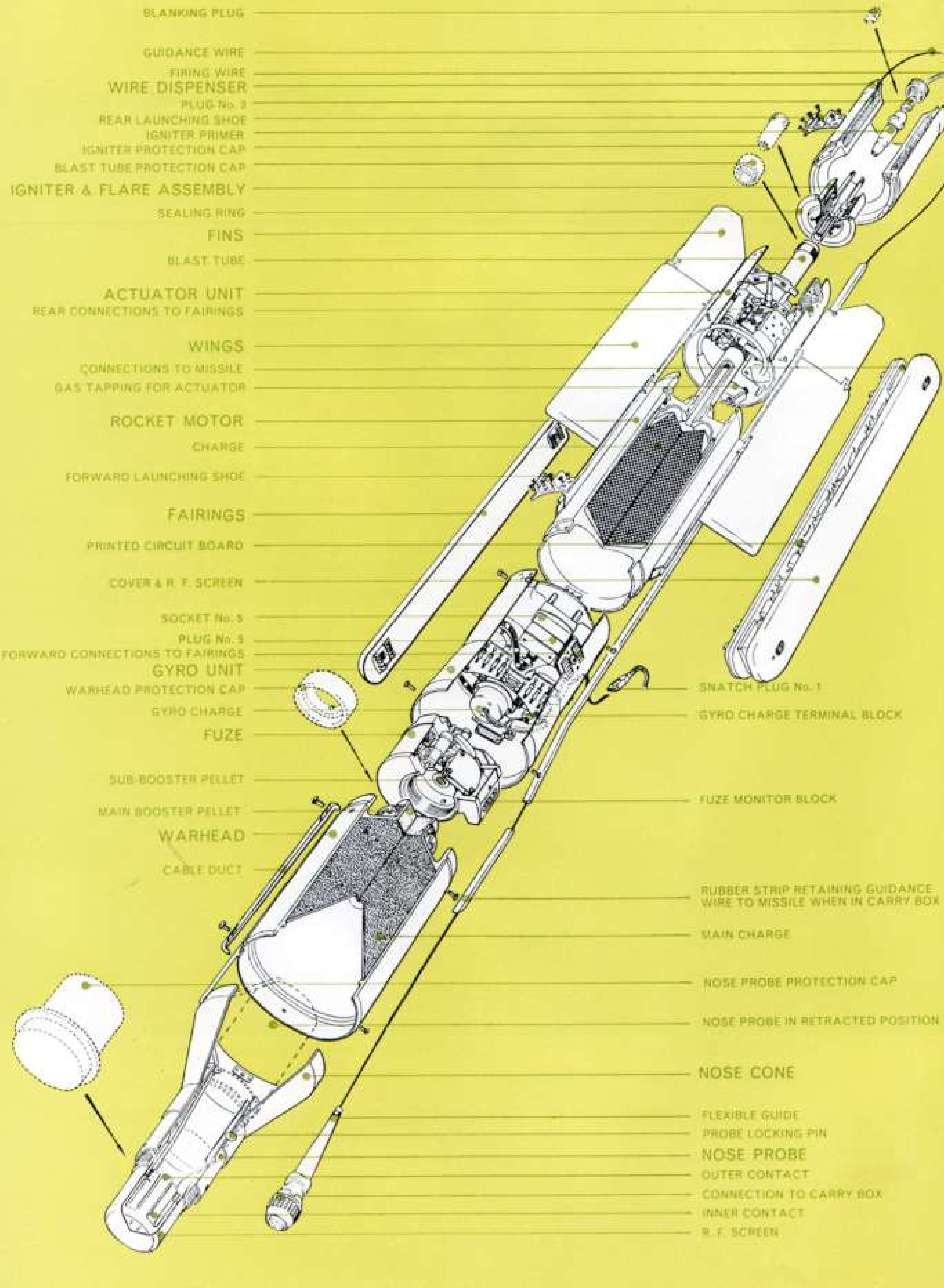
The autopilot controls powerful trailing edge flaps on each of Vigilant's four wings. These flaps are driven by gas actuators to give a very small turning radius. A sustained g-force of 6g is possible with Vigilant.

Propulsion is by a boost/sustainer rocket motor which rapidly accelerates the missile to flying speed and imparts a continual acceleration during the sustainer stage. The total time of flight, even for maximum range, is only about 12 seconds.

With Vigilant there is no flash and no smoke, making detection from the target very difficult and giving immunity to counter-measures.

The compact size of Vigilant makes it readily adaptable as an anti-tank armament for light fighting vehicles and helicopters. It can be used in commando or paratroop operations without any difficulties.

A realistic simulator trains operators to a high standard before they fire any missiles. It is normal for an operator after some five hours training on the simulator to obtain direct hits with the first live missile he fires.



BLANKING PLUG
GUIDANCE WIRE
FIRING WIRE
WIRE DISPENSER
PLUG No. 3
REAR LAUNCHING SHOE
IGNITER PRIMER
IGNITER PROTECTION CAP
BLAST TUBE PROTECTION CAP
IGNITER & FLARE ASSEMBLY
SEALING RING
FINS
BLAST TUBE
ACTUATOR UNIT
REAR CONNECTIONS TO FAIRINGS
WINGS
CONNECTIONS TO MISSILE
GAS TAPPING FOR ACTUATOR
ROCKET MOTOR
CHARGE
FORWARD LAUNCHING SHOE
FAIRINGS
PRINTED CIRCUIT BOARD
COVER & R. F. SCREEN
SOCKET No. 5
PLUG No. 5
FORWARD CONNECTIONS TO FAIRINGS
GYRO UNIT
WARHEAD PROTECTION CAP
GYRO CHARGE
FUZE
SUB-BOOSTER PELLET
MAIN BOOSTER PELLET
WARHEAD
CABLE DUCT
SNATCH PLUG No. 1
GYRO CHARGE TERMINAL BLOCK
FUZE MONITOR BLOCK
RUBBER STRIP RETAINING GUIDANCE WIRE TO MISSILE WHEN IN CARRY BOX
MAIN CHARGE
NOSE PROBE PROTECTION CAP
NOSE PROBE IN RETRACTED POSITION
NOSE CONE
FLEXIBLE GUIDE
PROBE LOCKING PIN
NOSE PROBE
OUTER CONTACT
CONNECTION TO CARRY BOX
INNER CONTACT
R. F. SCREEN

The Vigilant Weapon System comprises a missile in its launcher/carry box with separation wire, a hand held sight/controller and a small dry battery carried in a convenient uniform pocket.

The missile nose probe consists of two electrical contacts protected in flight by an R.F. screen. On target impact, the closing of the contacts initiates the firing sequence to explode the warhead. Electrical power for firing is provided by the missile's own internal supply.

The warhead is armed by an inertia switch which does not allow detonation to occur until at least 100 yards of flight has occurred. A mass weight is unlocked when the trigger is operated and moves under missile acceleration; a train of gears and a flywheel restricts the speed. This is a distance measuring device and is insensitive to missile accelerations which may differ in various temperature environments.

Immediately aft of the nose probe is the hollow charge warhead of 5 in. calibre. This is powerful enough to penetrate armour of all current tanks.

Further aft between the warhead and rocket motor is the gyro assembly. Two fully-gimballed gyros give a reference of the missile's attitude in flight in both pitch and yaw planes, and also measures the rate of roll, "designed in" at about four cycles per second.

A simple eight segment commutator resolves the pitch and yaw demands of the operator into corresponding demands to the missile control system which has a rotating axis reference. Thus, as the missile rotates, the control flaps will pivot from side to side as they alternately become elevators and rudders.

The gyro wheels are blasted to speed by jets of cordite gas impinging on peripheral machined buckets. The gas is derived from a small charge, fired when the operator pulls the trigger. As the gas pressure decays the gyro cages are unlocked and released to give a stable reference platform. The run-up and decage takes approximately half a second.

The pitch datum gimbal is inclined to the missile axis at 15° so that as the missile is launched at its normal altitude of 20°, automatic levelling off will occur and the missile will fly at its correct angle of wing incidence about 15 feet above the launch height.

The rocket motor body is the main structural member of the missile. The gyro assembly attaches at the forward end and the four wings on the outside slide into light alloy channel sections bonded to the motor.

The single chamber rocket motor is machined from a light alloy forging with an alloy steel blast pipe. A boost/sustainer charge is used to accelerate the missile rapidly to flying speed and thence to maintain a reduced acceleration throughout flight. Cast double-base propellent is used.

Hot gases are ejected rearwards through the blast pipe and nozzle. A combined igniter and flare unit screws on to the end of the blast pipe, without which the motor is safe. The flare is ignited by the hot blast pipe about $2\frac{1}{2}$ seconds after launch and besides assisting tracking, eliminates any smoke by after-burning.

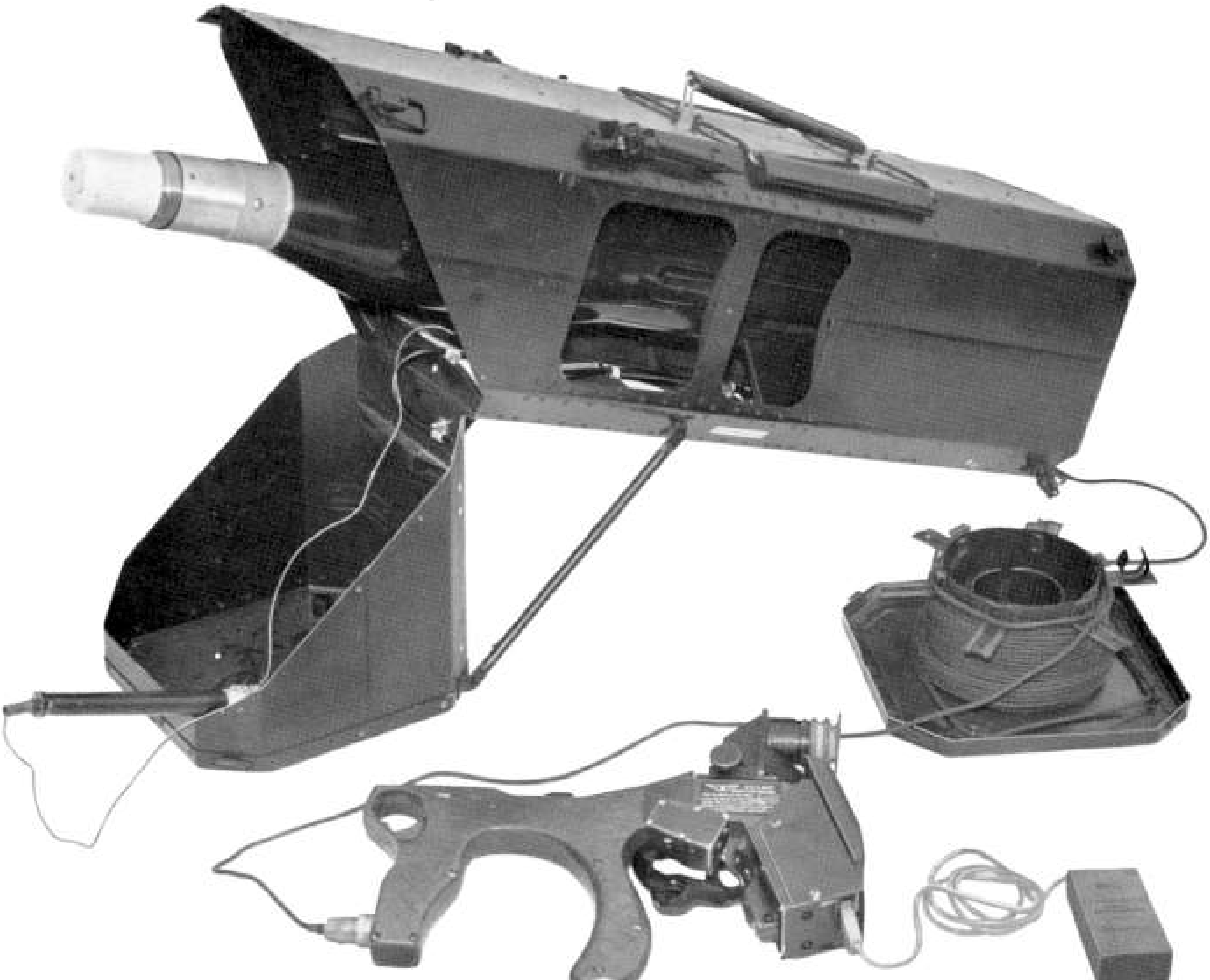
The wings are made from foam-filled resin-impregnated glass cloth to give a very light and strong structure. Low aspect ratio wings were chosen for compactness and to lessen any risk of grazing branches or the ground in flight. A very high angle of incidence is possible before the wing stalls and this adds a useful component of lateral thrust for violent manoeuvres.

Large flaps are hinged to the trailing edges of each of the wings. Flaps are much more effective and aerodynamically efficient than spoiler controls and on Vigilant give manoeuvres with 9g peaks when required.

Behind the rocket motor body, and around the blast pipe, fits the actuator assembly. Hot gas bled from the rocket motor provides power for the actuators, controlled by small poppet valves. Opposite pairs of control surfaces are interconnected—a simpler system than that required in roll-stabilised missiles.

A turbo-alternator to provide power for the missile electronics is also driven by hot gas from the main rocket motor. Speed is controlled to within $\pm 5\%$ by a centrifugal brake. The A.C. output is rectified by silicone-alloy diodes and smoothed. The four-core control wire which unwinds from the missile in flight is housed in a spool at the extreme end of the missile. It is dispensed through an annular slot to ensure there is no interference from the hot rocket motor gases.

The control system electronics are housed in two indentical fairings fitted along the outside of the missile with pick-up contacts in the actuator assembly and gyro assembly. A convenient link is thus made between the autopilot and actuators. Silicone transistors are used throughout for lightness, compactness and to avoid any warm-up delay. A wide temperature range is possible and reliability is further increased with printed circuitry. The entire assembly is sealed against moisture and is readily replaced by two screws should any fault occur. A system of repair by replacement is engineered into all Vigilant assemblies.



CARRY BOX/LAUNCHER

The carry box/launcher, which is provided with each missile on manufacture, is made of light alloy frames and outer skin with launcher rails suspended from the upper inside surface. During transit the missile is supported by these rails together with a C support, removed prior to firing. Two rails are used—one for a forward shoe on the missile and one for the aft. As the missile moves from the box, it is released simultaneously from both supports.

The front lid is secured by quick-release catches and hinges downwards to support the box at the correct launch angle of 20°. Telescopic struts hold the front lid rigidly when open.

The rear lid is similarly fastened and is removed to expose a drum of 7-core cable. The drum is turned and released from the rear lid so that the cable can be quickly unwound to the operator's selected firing point. Adequate measures have been taken to ensure that the lids are weatherproof.

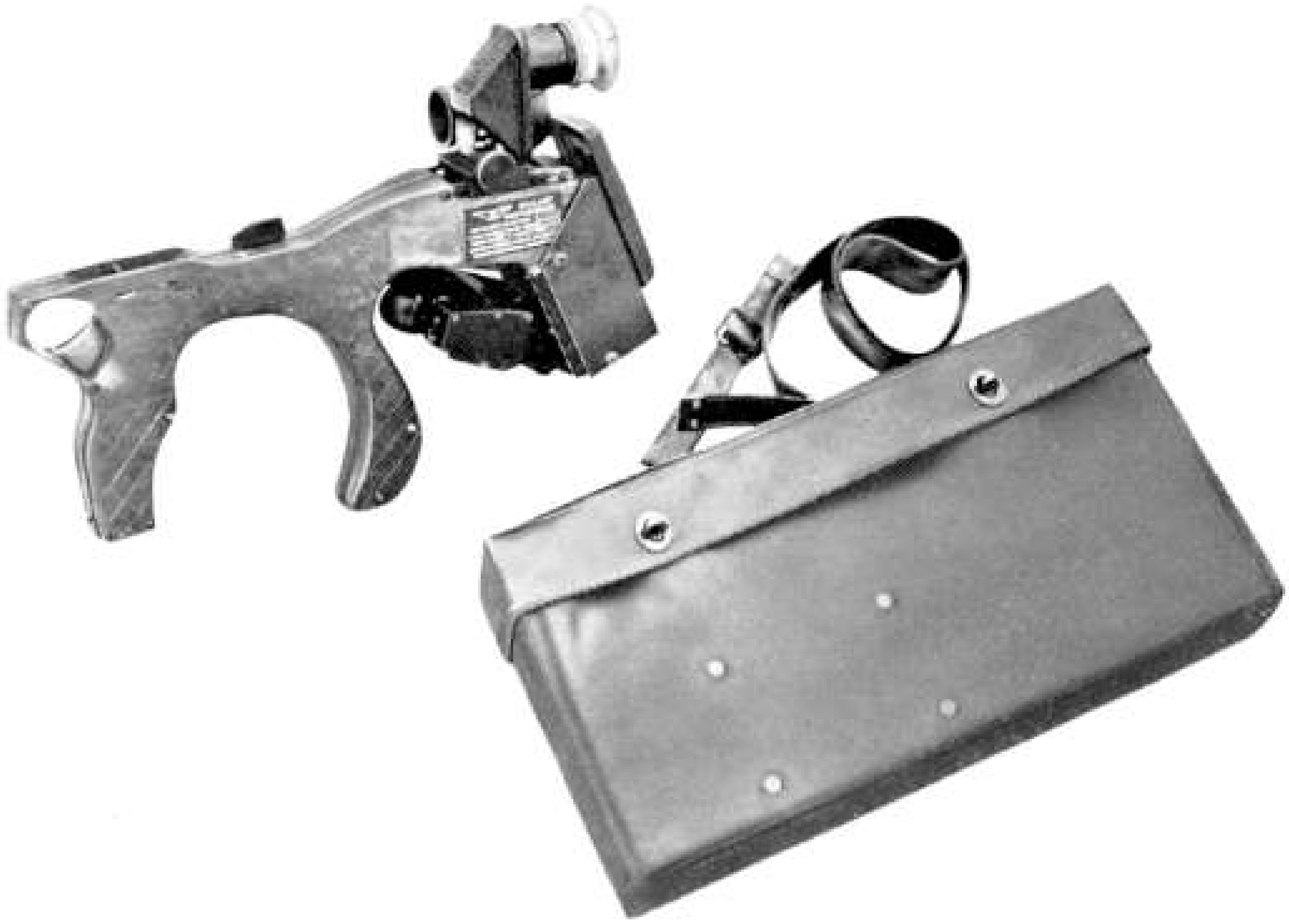
A guy rope with a spike is fitted on each upper edge of the box and are unwound and pushed into the ground to hold the launcher in a stable position.

Internal wiring of the box transfers the firing and control signals from the 7-core cable to the gyro charge and motor igniters and to the 4-core control wire stored in the rear of the missile. The control wire is fed into the missile from a light alloy tube support, stored and pivoted forward before firing, in the front lid.

Launcher/Carry boxes are normally returned to the manufacturers to be loaded with another missile.

SIGHT CONTROLLER

The sight/controller is made in two parts from glass-fibre reinforced polyester resin. A dye in the resin gives a dull green finish. Operator's controls are an arming switch, trigger, thumb controller and a bias switch which is used to bias the entire



control system either to the right or left for highly offset targets. A X5 monocular clamps on to the top of the equipment to assist in viewing distant targets. A cheek rest and moulded grips give comfort so that the operator can fully concentrate on guidance.

A linkage inside the controller ensures that the ground battery cannot be plugged in with the arming switch closed. Electrical components include capacitors for the firing circuit, charged in a few seconds by the ground battery and wire wound potentiometers linked to the thumb controller to give voltage potentials corresponding to pitch and yaw demands. The potentiometer voltages are processed before transmission to the missile to give correct " feel " characteristics to the operator.

A plastic case conveniently holds the sight/controller and monocular, with a shoulder strap attached.

GROUND BATTERY

A small layer-type dry battery with outputs of 48v and 24v provides power for the firing circuit and subsequent control signals to the missile in flight. The battery is normally carried in the uniform to protect it against extremes of temperature and so as to give as consistent a voltage as possible.

The capacity of the battery is sufficient for at least six firings.

Vigilant in its container will strap easily on to the standard infantry manpack carrier or alternatively a special shoulder harness may be used. For added convenience, handles on the carry box may be used by one or two persons for transit packing and unloading.

The setting up procedure which has been found most convenient is as follows :—

(1) Remove the rear lid with separation cable drum and fit the igniter/flare assembly if necessary.

(2) Remove the front lid locking the telescopic supports and rest the container on the ground.

Pivot forward the control wire support, extract the telescopic nose probe and unscrew its protective cap.

(3) Remove the C support from around the warhead section of the missile.

(4) Push the guy rope spikes into the ground.

The missile is then set up and the operator moves to his selected firing point up to 70 yards away, unreeling the separation wire as he goes. At the firing point, a plug on the end of the separation wire is inserted into the sight/controller and the lead from the ground battery plugged in.

FIRING AND CONTROLLING

Before operating the trigger, the arming switch must be closed for five seconds to charge the firing capacitors in the sight/controller.

As the trigger is squeezed, the first event in the launch sequence is the firing of the gyro charge. About half a second later, the rocket motor is ignited and the missile leaves it launcher with all internal supplies and electronics fully functioning. Levelling off occurs as flying speed is attained whence the operator takes over control to bring the missile on to his sight line.

The pyrotechnic flare ignites after about 2½ seconds, and the sustainer charge then slowly accelerates the missile so that maximum range of about a mile is reached some 12 seconds after launch.

Should the missile graze the ground or strike an obstruction such as a small branch the autopilot will immediately correct the disturbance and the missile will resume its original heading. In gusty conditions, the heading is similarly maintained thus relieving the operator from making continual corrections to course.

Detonation will occur when the nose probe is crushed on impact with the target.

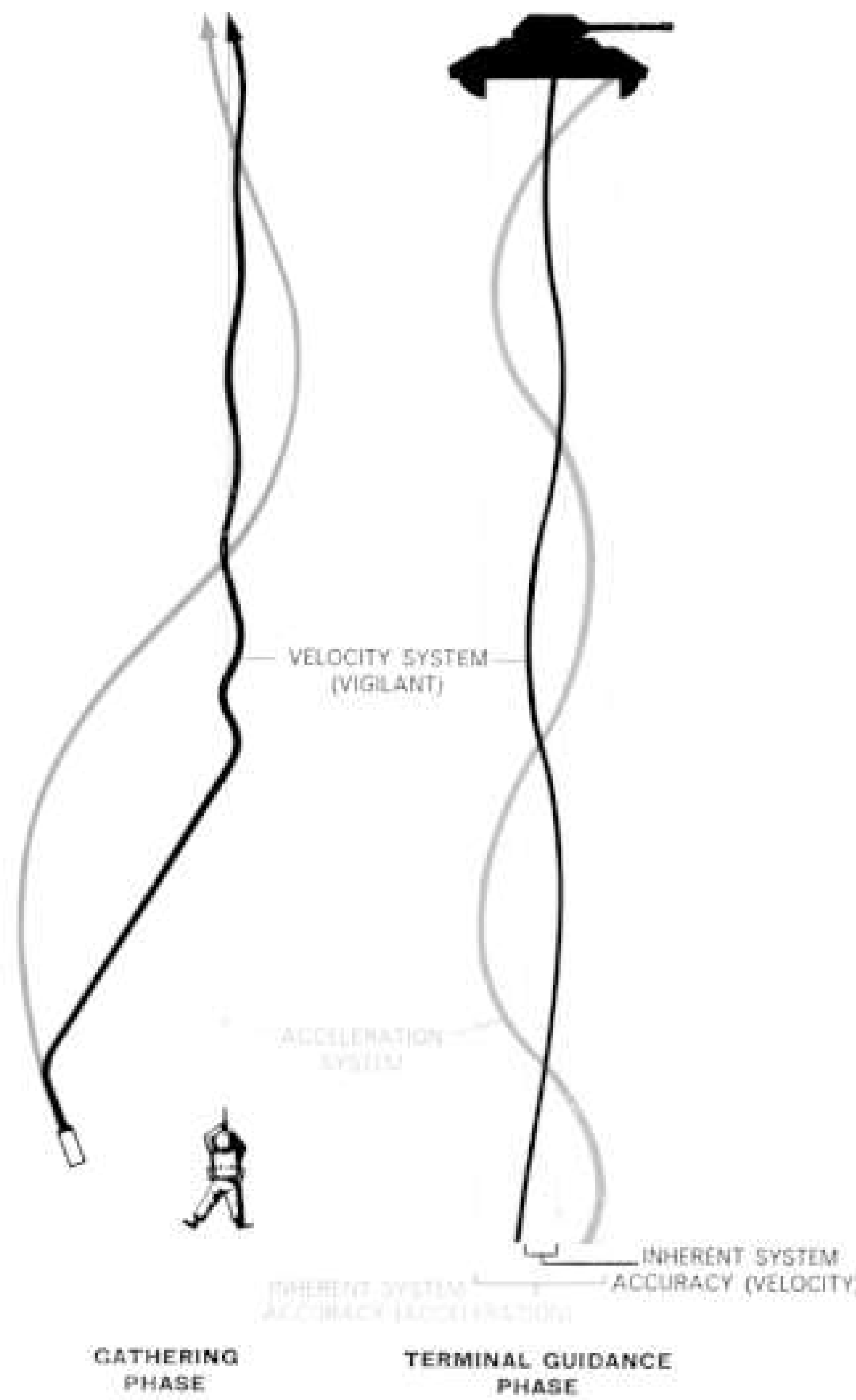
ACCURACY

The accuracy of any missile system depends on a number of factors. Most critical is the time delay in missile response after a control demand. With Vigilant, this delay is reduced to .4 secs. by a phase advance system which momentarily gives a very large control surface deflection to initiate missile rotation in space.

The amplitude of missile " weave " is proportional to the square of the delay period. In the case of Vigilant, the weave amplitude is smaller than the turret projection of the smallest tank enabling a point of impact to be chosen in the most vulnerable area.

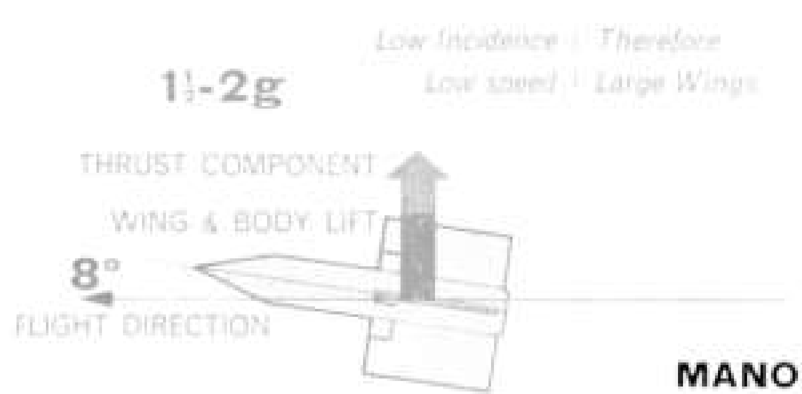
The relative speeds of target and missile should be as large as possible when moving targets are being attacked. The speed of Vigilant on impact at long ranges gives a speed relation between target and missile in the order of 20:1. The high speed of Vigilant also allows " snap " shooting at targets which may appear as hull-down tanks for only 10 or 15 secs.

Such snap shooting has been demonstrated several times against fast moving tanks.

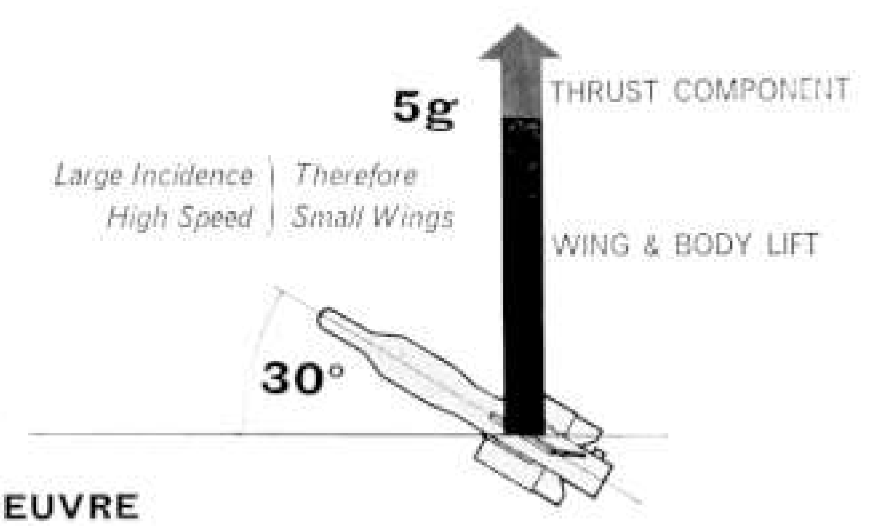


COMPARISON OF VELOCITY AND ACCELERATION CONTROL SYSTEMS

MANOEUVRE CAPABILITY



TYPICAL ACCELERATION MISSILE



VIGILANT

TACTICAL EMPLOYMENT

As an infantry weapon, Vigilant supplements short range Bazooka type rockets. Besides its operation by individual soldiers a Land Rover equipped with 12 Vigilants and four crew members may be the basic unit in the infantry division's anti-tank battalion. Re-supply by conventional transport or by light helicopters is both practical and immediately feasible.

In commando or paratroop operations, Vigilant can, for the first time, give anti-tank armament with the first troops. It can be brought into action in seconds against enemy armour thus reducing the risk of overwhelming fire-power of the enemy making a havoc of the landing. Conventional anti-tank guns are both bulky and heavy, and immediately give away their position at the first shot for a counter attack.

A battery of six missiles may be controlled by one man using a selector switch.

For fixed implacements, Vigilant is equally suitable as it does not need frequent testing and can easily be made weatherproof for long periods. A check at base camp once every six months is sufficient in temperate climates to ensure that the missile maintains its state of instant readiness.

In mountainous country where a direct view of attacking tanks is not available, the operator can use Vigilant in its standard form and control a ground launch from a helicopter up to 200 feet altitude. Alternatively, the helicopter can be fitted with its own rack-mounted missiles.

Standard Whirlwind helicopters can carry eight troops with two Vigilants each to the battle area. For longer range transport, a military Britannia can take 87 troops and 250 Vigilants for 3,000 miles. A Viscount can carry 60 men and 120 Vigilants for 800 miles, while a Belvedere helicopter can carry 25 troops and 50 missiles.

Light fighting vehicles such as the Ferret Scout Car are easily fitted with Vigilants. A current scheme is to have a Vigilant mounted on each side of the turret with further reserve missiles on the rear of the vehicle. Control is effected from inside the turret using a special wide angle periscope. Such armament greatly increases the tactical uses of Scout Cars.

SIMULATOR TRAINING AID

A projection type simulator has been developed to help in training on Vigilant and a simplified version is available for troop training.

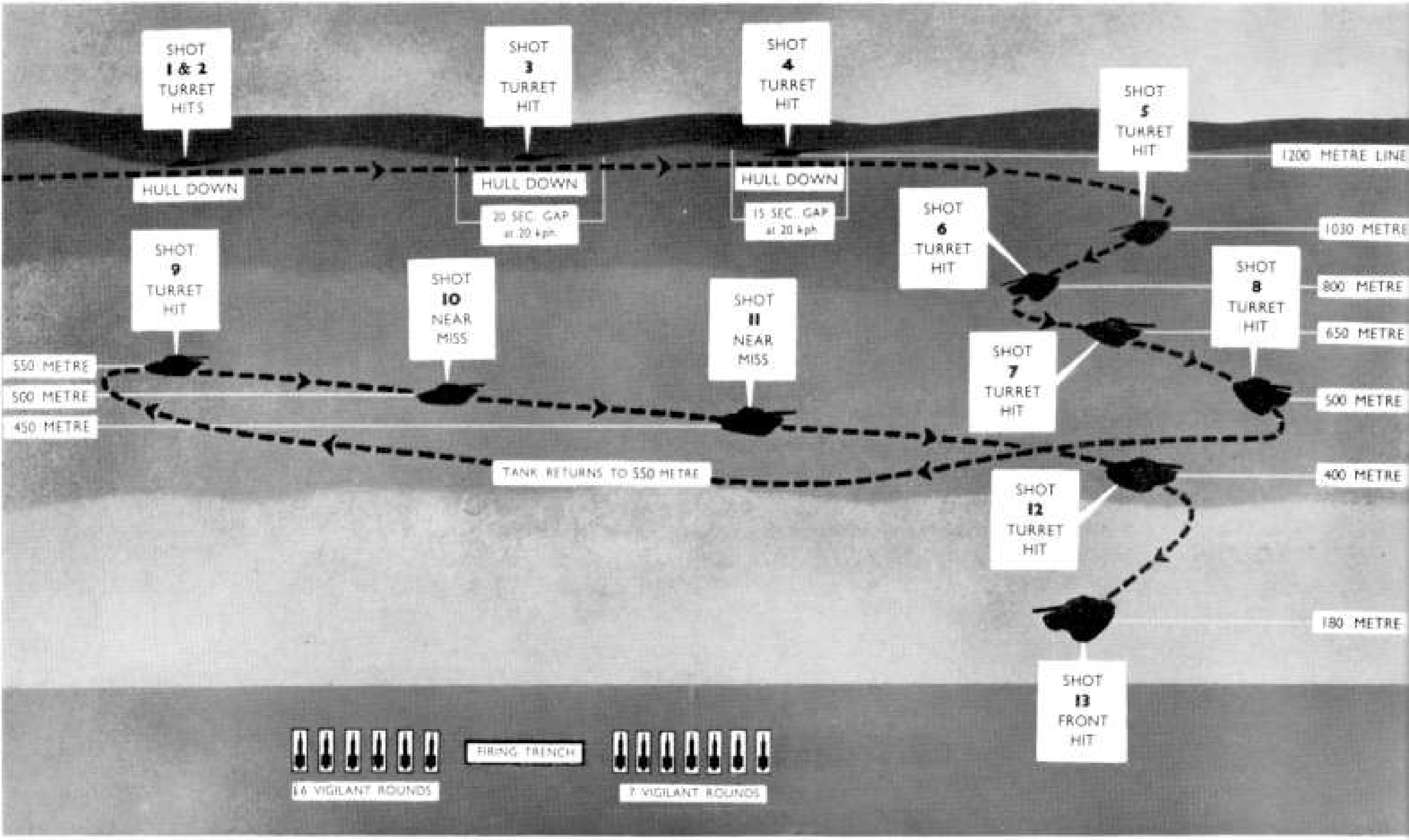
The basic principle is to deflect a spot of light by mirrors which are moved by demands from the sight controller. The spot is projected on to a spherical screen to give realistic simulation of Vigilant from any possible launch position and direction and with any separation.

As the missile is fired and recedes from the operator the spot of light is reduced in size with time of flight. A bell rings and the spot " freezes " for examination when the pre-set range has been reached.

A battlefield scene is normally projected on to the screen to add realism. Targets may be either fixed silhouette of tanks or moving silhouettes on a rail. Photo-electric cells on the targets aid evaluation of an operator's skill and progress in association with the Vickers Operational Performance Analyser. With this, the time to acquire sight line, number of traverses and time on sight line are recorded during flight to be examined after each run. Such an analyser can be used not only during the training programme but also to measure deterioration of skill after a lapse period and hence to devise re-training schedules for individual operators.

A transistorised version of the present type of simulator is under development to give a compact and portable unit.

Experience with the British Army has shown that approximately 5-7½ hours simulator training are sufficient for the average soldier.



European Demonstration

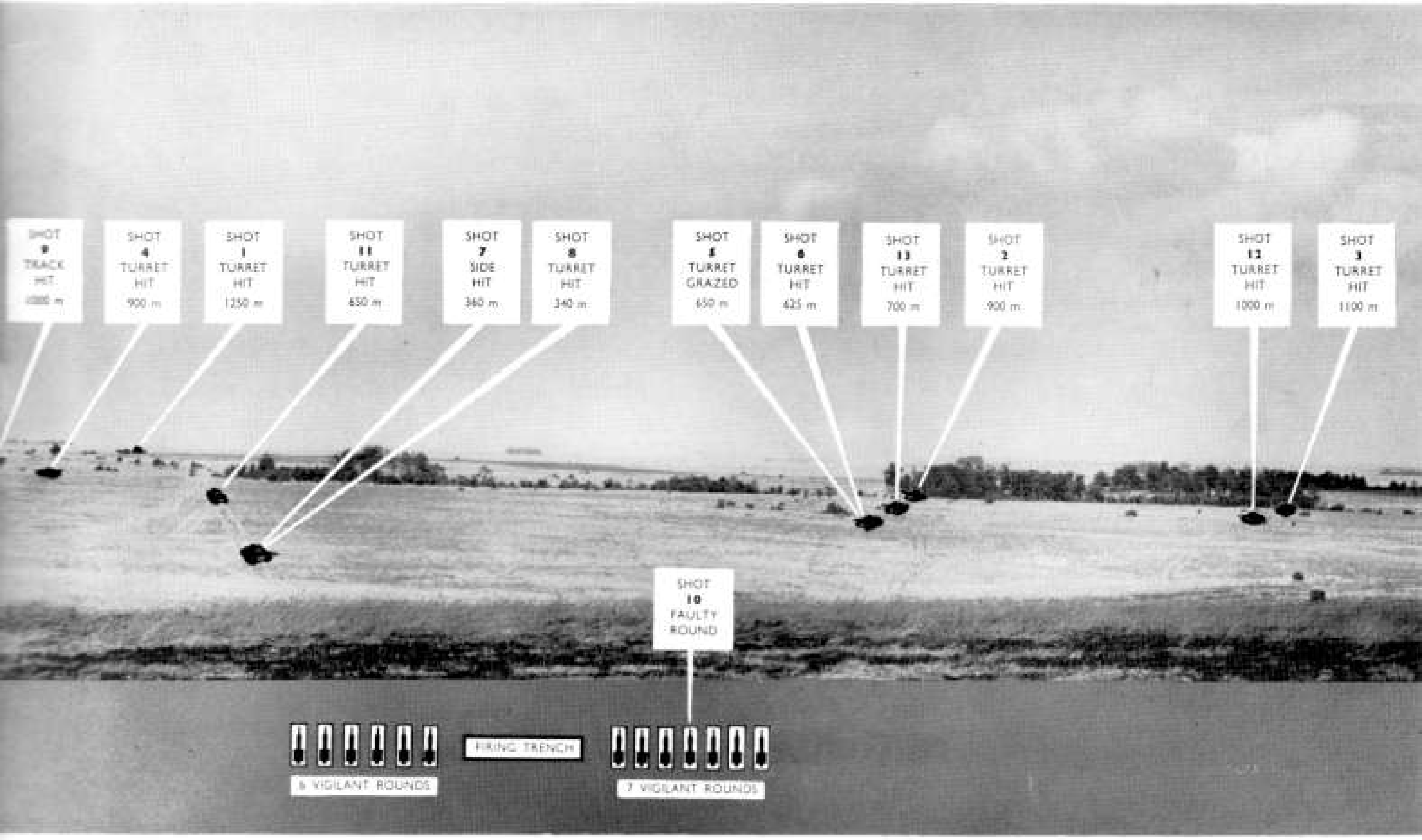
VIGILANT SUCCESSES

In the summer of 1961, Vigilant was demonstrated before a European Country's Army Staff and in England, to the Press and invited N.A.T.O. and foreign observers. At each demonstration, 13 missiles were fired. The results are shown most conveniently in panorama drawings.

An analysis of these rounds gives a reliability of 96% a hit probability exceeding 90%, and accuracy indicated by the number of turret hits.

The demonstrations included two operators landing from a helicopter, running with their missiles to the firing point and being ready to fire within 68 seconds. Subsequent firings scored direct hits.

These demonstrations have included firings at both moving and stationary hull-down tanks at ranges from 1250m. down to 180m. with various angular offsets. No other missile has been successfully demonstrated in public at ranges below 400 metres. Vigilant is alone in the anti-tank field in offering such range versatility, accuracy, reliability, training ease and overall cost.



Warminster Demonstration

VIGILANT COSTS

The cost of a missile must be taken on an overall basis to arrive at a figure of cost for objective. The objective with Vigilant is to secure a tank kill, taking account of training costs, reliability, accuracy and warhead lethality.

The training of Vigilant operators is almost entirely on the very realistic simulator. Recent British Army trainees all scored hits with their first missiles on moving tanks and the records of three average operators has given:

Operator A	...	...	12 hits out of 14
Operator B	...	...	9 hits out of 10
Operator C	...	...	9 hits out of 11

These firings included some trial shots which were designed to press Vigilant to the extreme of its parameters—they were not by any means simple targets. Many other missiles pose such a training problem that even after rigorous selection and simulator training, at least 12 missiles are fired before an operator is fully capable. By contrast only two firings of Vigilant are needed.

The reliability figure achieved in British Army trials has rapidly risen above 90% and is continuing to rise as large production batches are made under accurately controlled conditions.

The large number of tank hits that have been scored on the turret is ample support for the accuracy and lethality claims made for Vigilant.

Below is examined in more detail, the wide margins by which Vigilant leads in both efficiency and ease of training—margins which together make Vigilant easily the cheapest form of reliable infantry anti-tank defence.

VIGILANT EFFICIENCY AND ECONOMICS

The end of a tank

Vigilant has over a 95% missile reliability and a 90% record of hits on vulnerable parts of the tank.

Thus, in any batch of 100 Vigilants, 95 rounds will reach the target and 86 rounds will hit the tank in a vulnerable spot.

This performance is at least twice as good as that of any comparable infantry guided weapon.

Further, ordinary infantry soldiers have been Vigilant trained by five hours simulator practice and by the firings of two live rounds.

This is at least a **5 to 1** advantage to Vigilant in numbers of initial training rounds required.

Refresher training needs only one to two live rounds a year—again an advantage to Vigilant of at least **5 to 1.**

IN BATTLE

A commander needs less than half the number of Vigilants to do a given task than he needs of any other comparable weapon.

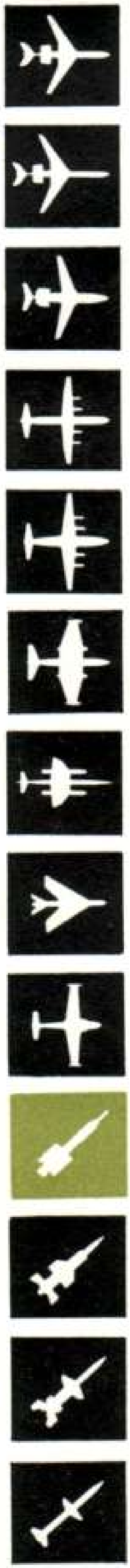
IN TRAINING

He needs less than one-fifth the number.

The above facts much more than compensate for Vigilant's higher unit cost and make it the cheapest infantry anti-tank weapon on offer in the world today. This is because, in the logistics of anti-tank weapon procurement, efficiency, accuracy and ease of training are much more significant than initial cost per round.

Finally, Vigilant can kill tanks over an angular coverage and at short ranges which are impossible to other similar weapons.

The Vigilant advantage here is infinite.



VC 10

Super VC 10

BAC One-Eleven

Vanguard

Viscount

Canberra

T.188

Lightning

Jet Provost

Vigilant

Thunderbird

Bloodhound

Blue Water

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