TABLE 3: AIR-TO-SURFACE MISSILES

	Propulsion		Length (ft)	Span (ft)	Body diam (in)	Launch wt (lb)	Range (n.m.)	Mach number	Warhead
	Type	Propellant							
Blue Steel I	Stentor rocket	HTP+K	35	13	50	15,000?	300?	2?	TN (4MT?)
ASM-N-7 Bullpup	Rocket	Storable liquid	10.5	3.1	12	571	3	2.4	250lb
GAM-83B Bullpup	Rocket	—	—	—	12	750+	5+	2+	N (10kT)
GAM-77 Hound Dog	J52 turbojet	K	42.5	12.1	28	9,600	435+	1.6	TN (4MT)
Nord AS-20	2-stage rocket	Cordite-type	8.5	2.6	9.84	309	3	1.7	73lb
Nord AS.30	2-stage rocket	Solid	12.4	3.3	13.4	1,125	6	2	505lb or N
GAM-72 Quail	J85 turbojet	JP-4	12.8	5.4	25	1,100	200	0.9	n.a.
Robot 304	2-stage rocket	Solid	14.75	6.7	19.4	1,200	3+	1	550lb
GAM-87A Skybolt	2-stage rocket	PU/AP	38	n.a.	35	11,300	1,000	9	TN (2MT)

tractors in 1958, and when specific design proposals were requested in 1959 Douglas Aircraft received a further contract to continue to study WS-138A. Before the year was out Douglas had awarded subcontracts to Aerojet-General for propulsion, General Electric for the re-entry vehicle and Northrop Nortronics Division for missile guidance. Douglas were awarded the prime contract for WS-138A in February 1960, and the programme has since moved on schedule.

At an early stage it was agreed that the principal carrier aircraft would be the Boeing B-52; the B-52H has been specially designed to carry this weapon system, and the B-52G and earlier versions can be adapted with modification. In April 1960 the British Minister of Defence announced that, Blue Streak having been cancelled, the British nuclear deterrent would be delivered by this system, and that he was negotiating for its purchase for RAF Bomber Command. In the latter service the carrier aircraft will be the Vulcan B.2. As reported in *Flight* of September 30, 1960, Douglas had studied the Victor as a carrier aircraft and found that "the installation problems would have been more severe, mainly because of ground clearance." Studies were also made of the Boeing KC-135, but the B-58 was not considered, and the planned B-70 posed kinetic-heating and separation problems.

Missile portion of WS-138A is GAM-87A Skybolt. The arduous structural design case of having to withstand flight manœuvres and (possibly) landing impacts, while suspended in a horizontal position from points along the upper edge, dictated a rigid airframe constructed along lines somewhat similar to the larger Minuteman. Two propulsion stages were found to be the optimum. Both contain a Polaris-type polyurethane-base propellant, which is kept at uniform temperature by an electric heating system operative up to the moment of release. Trajectory control is effected by swivelling second-stage nozzles, and the nozzle of the first stage is faired over until shortly after missile release by a drag-reducing tailcone.

Designed by Douglas, the B-52 pylon is bifurcated to carry two missiles (four or eight per aircraft). The weapons are staggered laterally to follow the sweep of the wing, to give minimum drag, and improve separation. During the outward flight the aircraft bombing and navigation system is continuously linked through the pre-launch computer to the guidance computer in the missile, and thence to the missile guidance system. In view of the brief flight time it is surprising that the inertial system requires stellar monitoring, but (as described in last year's review) a star-tracker is fitted with its telescope looking through a circular dark area 13ft from the nose of the missile. In fact, the star-tracker in each missile is probably a "belt and braces" method of determining launch position sufficiently accurately.

Missile trajectory starts with a free fall from the launch aircraft. The tail fairing is explosively jettisoned, the first-stage motor fired, and the missile pulled up into a climb—with or without a change in heading—ahead of the launch aircraft. Flight stability is improved by the eight delta fins, the four of reduced chord apparently being used to control the initial pull up into a climb and roll the missile through 180 . After stage-separation, the second-stage engine is fired, providing for precise trajectory control and thrust termination in order to place the re-entry vehicle on the desired ballistic trajectory. It will be noted that the final re-entry vehicle blends smoothly into the main missile body, like that of Jupiter; it is an entirely new ablative model, shorter and lighter than the original schemes reminiscent of the Mk 3 and Mk 4 re-entry vehicles of the ICBMs.

During the past year compatibility between WS-138A and the B-52H and Vulcan B.2 has been proved in all details. Dummy missiles were flown from Boeing's Wichita plant beneath a B-52G development aircraft on January 12, and the first drop tests of inert missiles were made over the Eglin Gulf Range in March. Vulcan B.2 compatibility tests began with a two-day electrical and electronic examination in Los Angeles in February, and were completed at Edwards AFB in July. It was then announced that "great progress" had been made in matching the missile to the Vulcan's bomb-nav system by means of relatively simple electronic circuits. The British aircraft carries one missile beneath each wing and in recent weeks has been seen so equipped over Britain.

At the time of writing, live firings down the Eglin Gulf Range are imminent, followed by full-range firings down the Atlantic Missile Range. Douglas have taken pains to restrict state-of-the-art advances in order to ensure that development proceeds on schedule; but financial juggling in Washington has led to a reduction in the pace of development. Funds for major subcontractors were slashed in January, and during Congressional Testimony in June the Director of Research and Engineering at the Department of Defense, Dr Herbert York, said that investigations by the Kennedy administration had shown that the $150m appropriated for WS-138A research and development before they took office would not suffice to carry the programme through 1961. Some $50m had been added, although the 1962 programme is still to be partially funded by money voted in 1961. Initial operational capability is scheduled for 1964 with SAC and 1965 with the RAF, but Dr York said recently "The Skybolt will be available at a later date . . . than it would be under a programme where the principle of concurrency was fully applied."

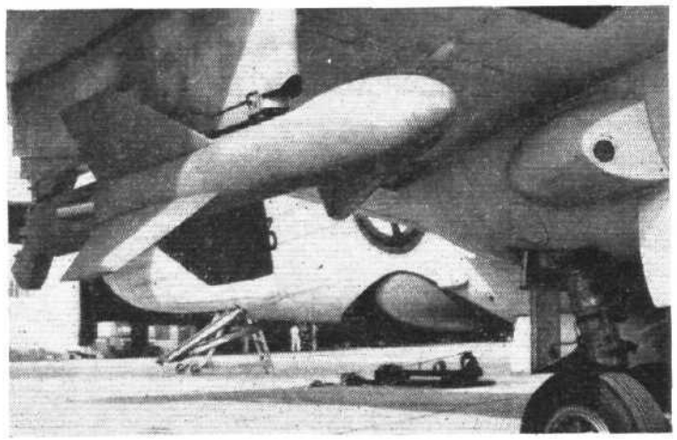
SOVIET MISSILES

OUR five previous reviews of the world's guided weapons have included not a word about Russian missiles launched from aircraft. Nothing was publicly known of such weapons outside the Soviet Union until the air display at Tushino last July 9, when no fewer than eight types of missile were seen matched to at least nine types of aircraft. Three of these missiles are portrayed in the Air-to-Air section of this review; one is a rocket used for ground attack by the new Kamov turbine-powered co-axial helicopter, and pictorial information is inadequate for us to attempt to draw it here; the other four missiles are included in the drawings on page 707.

By far the largest missile ever matched to an aeroplane is a 58ft weapon (sketch 13) carried beneath the fuselage of the Bear turboprop bomber. The wing is similar to that of the Fitter supersonic fighter; but, apart from the facts that the nose appears to house a radar, there is a ventral air intake and a very large propelling nozzle and that the cruising speed is probably about M2, little can be deduced. When converted to carry the missile the bomber has its nose filled with radar. So does the medium bomber Badger, the weapon for which (sketch 5) has an underslung package containing either one or two engines, and a range of some 300 miles. Drawing 11 is the M3 missile carried partially submerged beneath the new supersonic bomber known in the West as Beauty; propulsion is probably by a ramjet. Drawing 10 is a missile, carried beneath the wings of a Yak-25 development, which may equally serve in the air-to-air role.

WAGTAIL

ALTHOUGH a victim of the economy axe of 1957, this missile is still proving of singular technical interest. Under development by Minneapolis-Honeywell for the Air Force, Wagtail was designed for rearwards launching from a high-speed, low-level aircraft. The technique is now being investigated for ALBM and air-to-air missions.



Nord AS.12 carried by Breguet Alizé ASW and attack aircraft of the French Navy. This missile has radio guidance, in contrast to the wire guidance of the land-based SS.12