Krabbs

MAKING A TORSION BALANCE

NEWNES PRACTICAL MECHANICS

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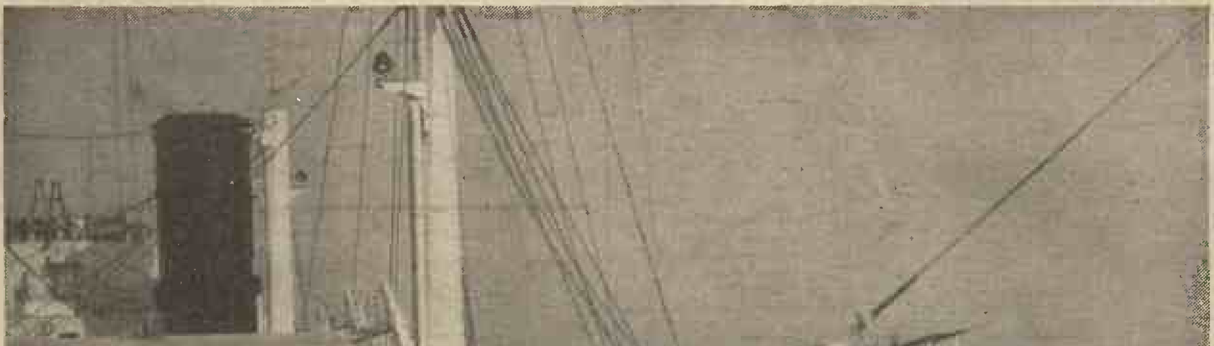


A WALRUS SPOTTING PLANE BEING CATAPULTED FROM THE WHALING SHIP *BALAENA* (*See page 96*)

Rocket Propulsion

Projected Rocket and Composite Rocket-athodyd Fighters

By K. W. GATLAND

(*Continued from page 53, November issue.*)

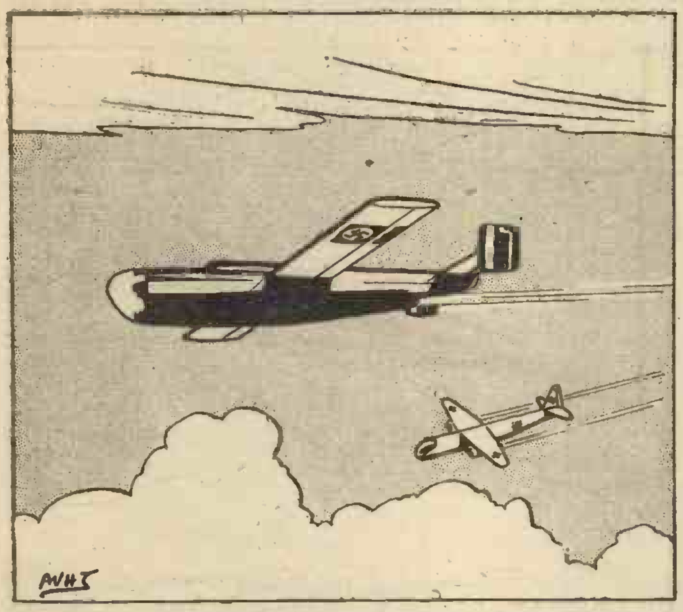


Fig. 82.—An Arado development in early stages of production at the time of the surrender. This tiny rocket fighter was to be carried into action beneath a jet-powered bomber.

ANOTHER special purpose fighter making use of the Walter 109-509A1 rocket engine was found under construction in the Arado works. This was an exceptionally tiny monoplane (Fig. 82), and its small proportions can be gauged from the fact that it could not accommodate the rocket unit in the extreme tail, a "step" having been embodied in the lower fuselage through which the exhaust emerged at a slight downward angle.

The mainplane had a high root fixing, and twin fins were fitted at the tips of an oblong tailplane. A prone piloting position helped to reduce the cross-sectional area of the fuselage and to delay critical "g" pressures, but most interesting of all was that it was intended to operate the machine from a jet-powered bomber.

Test flights had, in fact, already been made, using the then newly produced Arado 234C-1 as the parent. This four-engined "jet" was a particularly enterprising aeroplane, for despite a fully fuelled weight of 24,200lb., its maximum speed (between 530 and 550 m.p.h. at 20,000ft.) was greater than most of the fighters which accompanied Allied bombers. The tiny Arado fighter was fixed beneath its broad fuselage and, under combat conditions, would have been released just out of range of enemy fire.

In comparison with the designs which other manufacturers had in stages of project, the Arado development seemed no great departure from the orthodox. It was just another bold attempt to "out-fly" Allied aircraft, but like the majority of its contemporaries, came a trifle too late.

A further interesting project was the D.M.2 (Fig. 83), a rocket-powered flying-wing. Again, intended as a high-speed interceptor, this particular design was originally the work of Professor Lippisch, and was based on a standard pattern which had been evolved as the result of extensive tests with rocket-driven research models.

It was not simply a "tail-less" machine. There was no fuselage at all, the all-wing structure, thick in section at the root and tapering sharply towards the tips, sweeping back within a contained angle of 60 deg. A large vertical fin emerged on the centre-line at the rear.

The pilot was accommodated in a semi-prone position entirely within the contour of the wing section, and there was no cabin "blister" or other excrescencies to spoil the shape. His cabin afforded excellent vision in all directions except rearwards, the nose being completely covered with "clear-view" Plexiglas. Flight at high altitudes was made possible by pressurisation, supplied by three large oxygen cylinders.

The propulsion unit was of a type similar to that employed in the early versions of the Messerschmitt 163, known as the Walter R2-211. Its main difference was a more slender combustion unit to suit the thin wing section, having a smaller chamber and a long tapering nozzle. The tanks, designed to have a total capacity of 8,000 litres of T and C stoff, were naturally disposed over the c.g., so that balance would not be upset as the propellant was consumed.

A retractable tricycle undercarriage was embodied, the nose-wheel folding directly backwards between the pilot's heels, while the two main wheels came upwards, rotating through 90 degrees to lie flat in wells situated at the sides of the grouped engine accessories and behind the main propellant tanks.

It is obvious that the landing speed would have been high, and for this reason the designer had embodied a large flap area. The flaps, in fact, extended almost the entire length of the trailing edge, and it would appear that the outer pair also operated as elevons (single aerofoils serving the dual purpose of elevators and ailerons). A 2in. gap separated all control surfaces from the main structure, wing and fin, and this refinement in the case of the flaps was probably to increase the lift when they were lowered for landing as it permitted air from the upper wing surface to be deflected downward to supplement the under flow. The increased mass of air deflected when the elevons and rudder were operated made for increased sensitivity, which was particularly desirable for a machine of this type at low speeds.

The control column, which, owing to the prone piloting position was only about 1ft. 6in. high, was coupled to a servo gear to compensate for the decreased leverage.

Although no performance figures are available, it is obvious that the machine was intended to operate at high speeds, possibly bordering on supersonic speeds. It was, however, only one of several all-wing projects designed to Lippisch formulæ.

Another was an athodyd powered fighter with rocket booster (Fig. 84), said to be capable of travelling at 1,500 m.p.h. The remarkable feature of this machine was the fact that it used no fuel other than blocks of carbon, these being set inside a simple "straight-through" duct and preheated to incandescence just prior to flight. The pilot was to be installed near the nose, lying prone, the air entering from a central intake being ducted around his slim cockpit and flowing to the single heating chamber.

Launching was to have been by powerful assisted-take-off rockets, the machine accelerating along an inclined ramp, and once the air began to ram into the intake the high-velocity draught would serve to inflame the carbon, raising its own temperature in the process. At high speeds, large masses of air would be continually ramming through the duct and at a pressure so great to make any mechanical means of compression entirely superfluous. Expansion in the heating chamber would be rapid as the result of the intense heat thrown off by the carbon, the resulting jet finally emerging through a narrow slit in the trailing edge.

As far as is known, only model research had been conducted, but the numerous free-flight tests the Germans had been able to make in the few months available to them

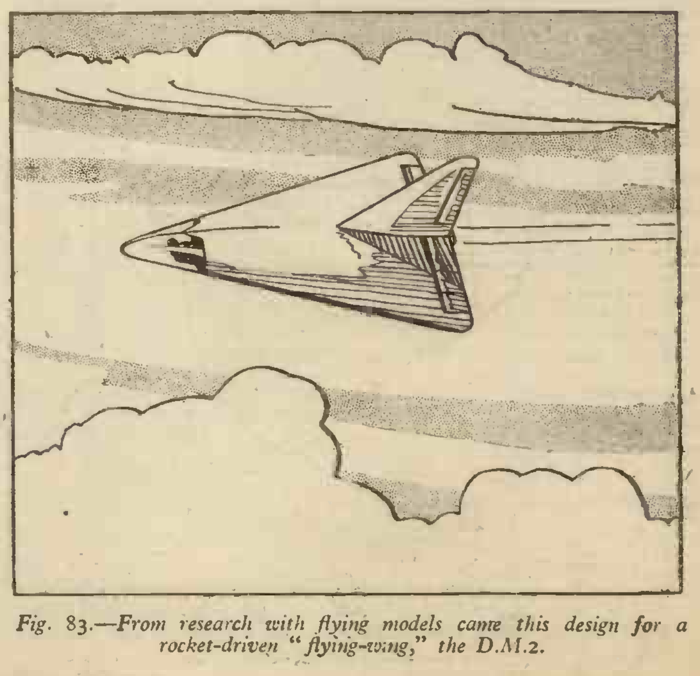


Fig. 83.—From research with flying models came this design for a rocket-driven "flying-wing," the D.M.2.

prior to the surrender would seem to have been particularly encouraging. The original experiments using carbon alone permitted a flight of 45 minutes' duration, but employing a paraffin spray to prolong the life of the heating blocks, the period of power was said to be virtually doubled. With this system, however, there would have been little opportunity for varying the thrust, although two possibilities that come to mind are the obvious ones: (a) of varying the area of the exhaust duct, and (b) the provision of bypass ducts so that a proportion of the air could be deflected away from the heating chamber should it be desired to "throttle-down."

A further machine making use of athodyd propulsion was one projected by the Focke-Wulf company (Fig. 85). This was a type not far removed from the normal high-performance fighter, though with two outstanding differences, namely, a 45-degree wing sweep-back and the unique mounting of its two propulsive ducts.

The fuselage was exceptionally slim, tapering smoothly to almost a point at the nose. The shape of the rear was almost identical but the provision of a rocket unit had necessitated a slightly larger section towards the tail. A neat "Plexiglas" hood emerged slightly more than half-way back from the nose, the single fin joining the line of the cabin and projecting beyond the fuselage end.

The tail-plane itself raked back at an even greater angle than the wings, and at its tips were fitted the two 4.4ft. diameter athodyds, an arrangement made possible by their light weight. This must have involved something of a nightmare for the company's stress department, and it is clear that the necessity for a strong angular transport member was the main reason for the acute tail sweep-back. It did not, however, interfere with the control system, which remained orthodox with normal rudder and elevators.

The Walter bifuel rocket engine developed a thrust of 6,600lb. and was to be used in take-off to accelerate the machine to the speed at which the ram pressure was sufficient to operate the ducts. A kerosene fuel was specified as the heating agent, the resulting jet to provide a 680 m.p.h. top speed at sea-level and a climbing rate of 31,000ft. per minute at 3,000ft. If, however, the 'plane was climbed to 36,000ft., the maximum speed in level flight would fall to 590 m.p.h., and naturally the climbing rate also suffered a loss, reducing to 5,100ft. per minute.

In consequence, it is suspected that the rocket system would have its main purpose in boosting the climb, and it is obvious that it would have been employed also in landing as athodyd units cut out at about 200 m.p.h.

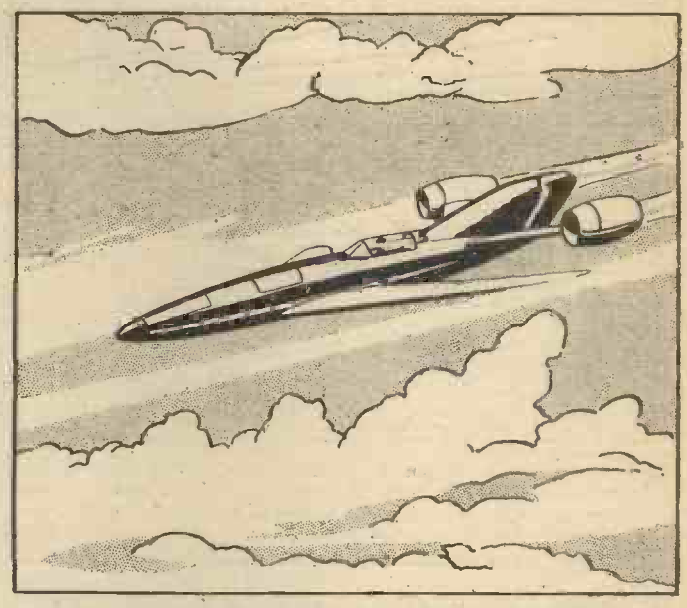


Fig. 85.—A "tail-drive" athodyd project from the Focke-Wulf stable.

At sea-level, the machine was said to be able to fly under full power for 13 minutes, but this could be much improved by a direct climb to 36,000ft., when 43 minutes' endurance could be expected.

The main weights and dimensions given in the design tender are as follows: an empty weight of 5,900lb., and a fully loaded weight (including fuel and pilot) of 12,000lb. The wings had an area of 205 sq. ft.

A High-speed Helicopter

As the war in Europe drew to a close, yet another design for an athodyd fighter was taking shape in the Focke-Wulf project office, this time a high-speed helicopter (Fig. 86).

Of all the schemes, this was by far the most unorthodox, for it was an entirely new approach in aircraft design. The machine embodied a nicely streamlined fuselage with the pilot contained in the extreme nose, but there all semblance of conventionality ended. It was intended to stand vertically on wheels mounted on its four fins and tail fuselage and to take off from that position with the aid of a three-blade rotor which revolved *around the fuselage*. This rotor was unique in itself, for it had no means of internal drive. Its propulsion arose from athodyds mounted at each blade tip, and once started by rockets these would cause the rotor to spin round at high speed.

The launching procedure would consist first in driving the rotor up to a speed at which the athodyds could operate. The blades would be set to give zero thrust during this operation and thus the ducts could be functioned without causing the machine to lift.

Within a few seconds the ducts would be working smoothly and the pilot had then only to operate a control to cause the blades to assume a slight angular pitch sufficient for the machine to rise gently upward. The vertical speed could be increased to a maximum of about 75 m.p.h., and having gained sufficient height, the machine would be turned into a horizontal path by deflecting its rudders and elevators, appearing as in Fig. 86.

An increase in the blade pitch would progressively improve the forward component of the duct thrust, the rotational speed of the rotor naturally falling as the result of the greater load.

At sea-level, the maximum speed expected was 620 m.p.h., the rotor operating at 520 r.p.m., which in terms of the speed would be 690 m.p.h. The initial rate of climb quoted is 25,000ft. per minute, with an endurance of 0.7 hours and a 400-mile range. At an altitude of 36,000ft., however, the forward speed would be 520 m.p.h., the duration 2.3 hours, the range 1,100 miles, and the climbing rate only 4,000ft. per minute.

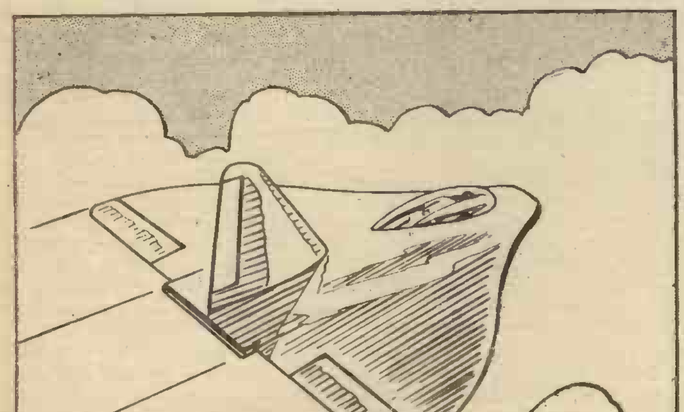


Fig. 84.—1,500 miles per hour—and on no other fuel than solid carbon. That was the estimate made by Professor Lippish for this athodyd-powered "flying-wing."

The descent was just the take-off procedure in reverse, the machine coming to rest gently on its tail—or so it was said. How it was proposed to remove the pilot from his precarious position remains a mystery.

The *profile drag* of this design was said to be about one-fifth that of a normal machine of the same dimensions, but the *induced drag* would have been twice as great as a wing equal in span to the diameter of the rotor—37.4ft. The ducts themselves were little more than 2ft. in diameter and involved practically no resistance.

The structural weight was 7,000lb., somewhat greater than that specified for the previous Focke-Wulf project, while the all-up weight at take-off was 11,400lb.

Other Athodyd Proposals

The projects illustrated in these pages were by no means the only ones to be based on athodyd propulsion. There was, for instance, the Heinkel P.1080, a tail-less machine with swept-back wings and two duct units, 16ft. long and extending quite two-thirds its overall length, fitted at each wing joint.

At the Skoda works was being planned an athodyd fighter in which a 31ft. Saenger duct formed the basis of its bulky fuselage. The general layout, however, was orthodox, with a mid-wing fixing and a single vertical fin on which the tail-plane was mounted just above its root fixing at the rear.

A nose cockpit enclosure was incorporated above the intake duct in which the pilot was to lie prone. There was provision for a heavy calibre cannon to be mounted just above his head, and a large capacity fuel tank, also installed on top of the duct, took up a position over the aircraft's c.g.

The machine was estimated to have a sea-level speed of 630 m.p.h., with a maximum thrust of 9,700lb.

Yet another proposal was for an adaption

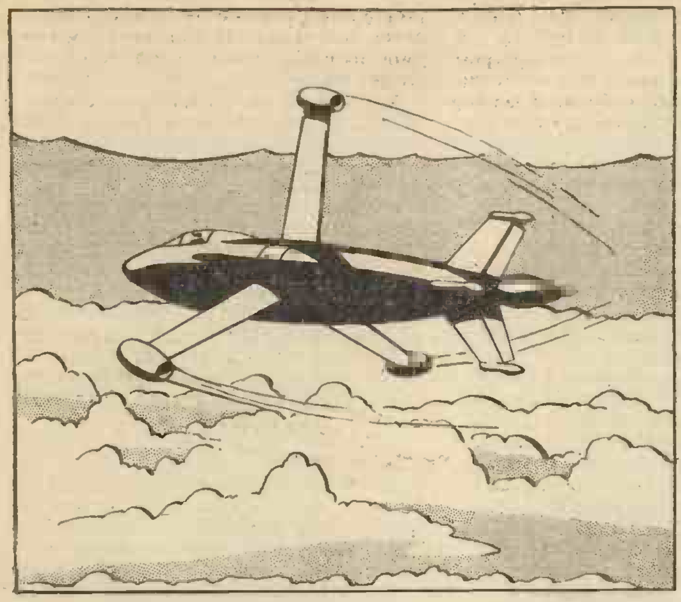


Fig. 86.—Another Focke-wulf project, this time a high-speed helicopter. Three athodyds were to drive its rotor, but most unorthodox of all, the machine was to stand vertical on wheels fitted in the tail-end. It would rise directly upward and then operate in horizontal flight, travelling at a maximum speed of 620 miles per hour.

of the Messerschmitt 262 with two Saenger athodyds in addition to its standard Jumo 004 turbo-jet units. The performance figures derived for this combination, however, were not particularly encouraging. The maximum speed at sea-level was estimated to be 620 m.p.h., but the climb to 36,000ft. would have taken over six minutes with fuel consumed within 40 minutes.

Summary

The foregoing is some slight indication of what promises for the future, though undoubtedly a great deal of further research will be required before the athodyd becomes a practical means of aircraft propulsion.

In very high-speed aircraft, the prospects are particularly great, for it has been calculated that at speeds upwards of Mach 1.4 and at a height of 40,000ft., the athodyd will develop a greater thrust per square foot of frontal area than the most efficient turbo-jet.

There are, however, serious obstacles. Even at quite high forward velocities, the athodyd's fuel consumption is between 50 to 100 per cent. greater than that of the mechanical-compression type.

It loses power with height because, unlike the rocket and turbo-jet, it is not "supercharged." The performance figures quoted for the Focke-Wulf "tail-drive" fighter tell their own story; a reduction of 90 m.p.h. from top speed at sea-level was registered at 36,000ft., while the climbing rate for the same conditions involved a loss of 25,900ft. per minute. For efficient operation, it is clear that a rocket booster is essential, and although extra tankage would be required to contain the rocket propellant, the fuel needed for the athodyd could be much less.

The higher the speed of the athodyd, the greater is the thermal efficiency. A speed of 1,300 m.p.h. at sea-level would produce an intake pressure of about 60lb./sq. in. (a figure which compares favourably with the 4-to-1 compression ratio of our best turbo-jets) with the fuel consumption then also a more reasonable proposition.

The U.S. Navy Department was one of the first to produce working examples of the athodyd. A number of various applications have been tried, and among the most successful were athodyd projectiles weighing 70lb. and capable of speeds up to 1,500 m.p.h.

An interesting point about them is that they required no auxiliary fuel feed. The fuel was contained simply within a double-walled liner positioned over the heating chamber, and it was only necessary to pre-heat this tank to cause the fuel to start issuing through the burner jets as the result of its own expansion.

Ignition

The jets were ignited immediately and the missile fired into the air with the aid of its auxiliary rocket. Its speed would quickly become sufficient for the ram pressure to take over, the high temperature created by the burners in the pressurised region producing expansion and jet reaction. The self-feeding process naturally continued throughout.

(To be continued.)

Modern Abrasives

Their Composition, Manufacture and Uses

THERE is no doubt of the fact that man has always been an abrasive-using animal. For, from far back in the mists of remote antiquity there have come to us man-made tools and implements which, crude although they may be, show unmistakably the marks of a rubbing-down process which has been applied to them.

The stone arrow, the ancient axe, the first attempts at the fashioning of knives and other metallic cutting instruments must all have been submitted to some process of grinding and shaping, and, indeed, on many of these prehistoric articles the actual marks of the grinding implement can be plainly seen.

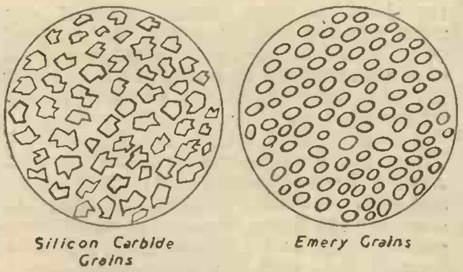
The earliest form of grinding, which, incidentally, has persisted right up to the present day, consisted in the rubbing of one thing over another, as, for instance, the frictional contact of one stone across another one of similar or, perhaps, harder texture.

Common Grindstone

The common grindstone forms an example of this, the earliest of abrasive operations. Actually, however, the grindstone as an abrasive agent is not a very efficient article, for it neither grinds nor cuts. The traditional grindstone merely rubs the article against it and exerts rather a haphazard tearing-away action on the object than a true grinding effect.

The first real scientific advance in the application of abrasives came with the more general utilisation of emery and its making up into compact stones and grinding wheels.

Emery is, of course, a naturally occurring mineral which has been known (yet surprisingly little used) for thousands of years. It occurs plentifully in Greece and, indeed, it derives its name from Cape Emeri, in the Greek island of Naxos, near which it was once mined.



Emery grains wear round with frictional rubbing, but grains of silicon carbide (carborundum) split under friction and continually present fresh cutting edges.

In composition, emery is an impure form of aluminium oxide mixed with iron oxide. It is reasonably tough without being unduly brittle and, although at the present time it has to meet much competition from the synthetic abrasive agents, it still retains its many large-scale and commercial uses.

Powdered flint used at one time to be a favourite abrasive, but such material is now less used, in view of the varying nature of its composition and physical characteristics.

Garnet

Garnet, however, is a natural abrasive material which still has its uses. In composition it is a silicate of aluminium mixed with iron oxide, resembling in this direction the precious stone, which is a crystallised form of it. Abrasive garnet, however, usually occurs in the form of a gravel, which is washed, ground, and carefully graded as to particle size and employed either as a substitute for emery or in admixture with it.

Sand, of course, has long been employed as an abrasive, as witness, for example, the now almost traditional sandpaper. So, also, have powdered glass, brick dust, and similar materials, although, strictly speaking, the particles of these substances exert a tearing rather than a true abrasive action.

The era of modern abrasive materials was initiated, perhaps, by the coming of carborundum, or silicon carbide, a material which was invented by the American chemist, Edward Goodrich Acheson, in 1891. This nowadays well-known and, indeed, indispensable material is made by fusing in an electric resistance-furnace a mixture of coke and sand, together with a little salt to make the mass more readily fusible and a small quantity of sawdust to render it porous.

During the 36 hours of continuous fusing which the manufacture of carborundum requires, a temperature of no less than 3,500 degrees C. is reached, a terrific heat