FIG. 1—REMOVAL OF HEAVY RISER FROM STEEL CASTING BY STANDARD LANCE

OXYGEN LANCING TECHNIQUES

STANDARD LANCE : THERMIC BORING : POWDER LANCE

BY

F. CLARK, M.B.E., M.INST.W. AND E. T. CASEY, A.M.INST.W.

Some officers engaged in various operations of World War II may remember the difficulties they encountered in demolition. It is hoped that such a situation will not recur, but the need to ' demolish ' is not always caused by war and this article should prove of value and interest. The Authors are members of the Staff of British Oxygen Gases Limited, and gratefully acknowledge the permission of the Directors to publish this article.

The oxygen lancing technique was introduced to industry in the early days of oxygen cutting as a method for breaking up heavy sections of steel and cast iron. This method, however, is confined to materials containing a very high percentage of iron. In recent years, two other techniques, known as Thermic Boring and Powder Lancing, have been developed to deal with non-ferrous metals and non-metallic materials, such as concrete.

In the normal lancing operation, oxygen is fed to the reaction zone through a length of $\frac{1}{4}$ in. bore gas barrel which is consumed as the boring or cutting action proceeds. The procedure is to heat a small spot on the surface of the iron or steel to be lanced, by means of an oxy-acetylene blowpipe and when ignition temperature is reached (bright cherry-red in colour) to switch on the oxygen supply and feed the lance into the hole formed. The oxide produced is very fluid and flows readily from the hole even after several feet have been bored. Once the lancing action has been started the iron-oxygen reaction is sufficient to enable holes to be bored or rough cuts to be made in ferrous metals ; a fuel gas, such as acetylene, is not required to support the reaction as in normal oxygen cutting.

This technique is widely used at the present time in the steel industry for breaking up old ladle skulls, etc., opening holes in the frozen metal in the tap holes of blast and open hearth furnaces and for removing heavy risers from castings (FIG. 1).

The thermo-chemical reaction produced by this method, however, is insufficient to have any appreciable effect on non-ferrous metals and non-metallic materials such as rock.

During the years preceding the Second World War various experiments were conducted in this and other countries in an attempt to develop a thermal method to help in the demolition of concrete, but although it was realized that the lancing technique was the most likely to succeed, no tangible results were achieved. It was therefore left to a combination of circumstances brought about by the Second World War to put thermic boring of concrete ‘ on the map ’.

During the occupation of France, the Germans used millions of tons of concrete to erect the enormous gun emplacements, air raid shelters, U-boat pens and other structures which constituted the allegedly impregnable Atlantic Wall. As soon as the Germans were driven out of France in 1944–1945, the French set about demolishing the huge masses of concrete, a large percentage of which was not reinforced, but ordinary and in parts rather inferior concrete. In normal times compressor-driven pneumatic drills would have been quite suitable for the job but the French were desperately short of compressors to drive the drills, and petrol to drive the compressors, and so any other means of breaking up concrete was worthy of the most serious consideration. The possible use of the oxygen lance was therefore further explored by the French and, in the ensuing operations, the Thermic boring process was developed.

In February, 1947, a paper was read at the joint meeting of the Institution of Structural Engineers and of the British Section of the Société des Ingénieurs Civils de France by the president of the French Society of Welding Engineers, M. Maurice Lebun, which described the work done in this connection with oxy-thermic boring. This paper aroused considerable interest in this country, and although it did not seem to indicate that thermic boring would ever supersede pneumatic drilling, it did appear that a definite field of utility existed.

The general principle of the system is an adaptation of the use of the iron-oxygen reaction to meet practical requirements where the boring of concrete, especially steel reinforced concrete, stone or other materials is required. Previous experiments, making use of standard lancing equipment, had shown that the thermo-chemical reaction produced by the use of $\frac{1}{4}$ in. gas barrel was insufficient to have any appreciable effect on concrete. The problem was solved simply by feeding a greater amount of iron into the reaction zone, and this is achieved by packing the gas barrel along its entire length with mild steel rods. The size of rod employed is important since, in the first place, the space between the packed rods must be sufficient to allow the required amount of oxygen to pass for the chemical reaction to be maintained, and secondly, to ensure that the rods and gas barrel are consumed at the same rate.

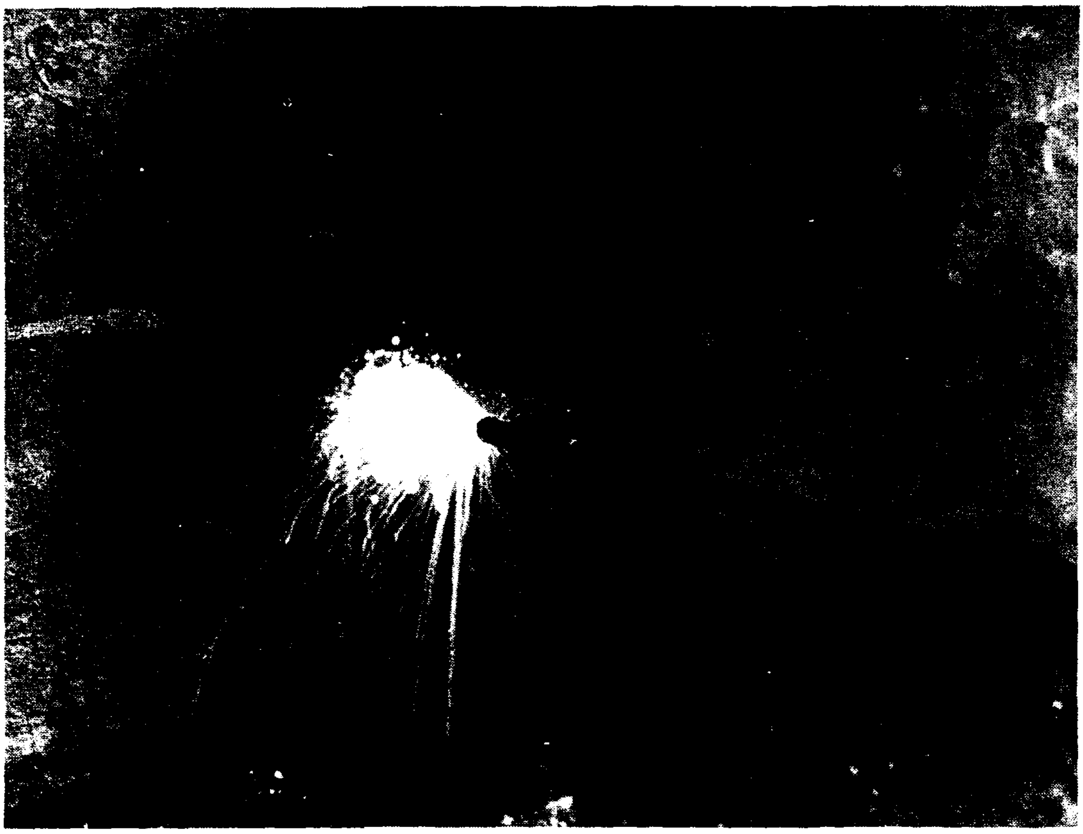

FIG. 2—THE PACKING LANCE IGNITED

The tubes used are standard gas pipes and the sizes most commonly used are $\frac{3}{8}$ in. and $\frac{3}{4}$ in. in 10 ft lengths, although in special cases up to 2 in. diameter pipes have been used. The most suitable size of rod with which to pack these tubes is $\frac{1}{8}$ in. diameter which is about the same diameter as the wall thickness of the tubes.

Approximately, the flow of oxygen occupies 35 per cent of the internal cross section of the $\frac{3}{8}$ in. tube, and 25 per cent of the $\frac{3}{4}$ in. tube.

Equipment

The supply of oxygen is usually obtained from cylinders of 2,000 cu ft capacity or from a number of smaller cylinders interconnected by suitable couplings to a pressure reducing regulator.

The lance holder, which is connected to the oxygen regulator by means of rubber tubing, consists of a holder approximately 15 in. in length fitted at one end with an oxygen valve and at the other end with a threaded sleeve into which the packed lance is inserted.

The packed lance tubes are threaded at each end for screwing into the lance holder and also for joining two lengths together, if necessary, by means of a standard socket.

Method of Use

The thermic boring technique differs from the normal lancing method in respect of starting the reaction. In normal oxygen lancing a spot on the metal to be lanced has to be preheated to obtain the reaction and should the tip of the

FIG. 3—THERMIC BORING A COPPER FURNACE BEAR

lance be withdrawn too far the reaction will cease. In the case of thermic boring the point of the lance is preheated by means of an oxy-acetylene burner or some other method, and when ignition temperature is reached the oxygen is fed through the lance promoting fusion at the lance point. The reaction is then self-supporting as shown in FIG. 2. The lance point is then applied to the material to be penetrated and the heat generated fuses the lance and the concrete, the flow of the slag being assisted by the molten metal of the lance and by the high velocity oxygen stream.

The boring operation is not difficult, the lance is simply fed into the hole and the operator quickly learns the correct amount of pressure to apply to achieve the best results. During the lancing operation the slag produced is quite fluid, but on cooling it is very brittle which makes it easy to remove. There is none of the tenacity which characterizes the slag produced when lancing steel or cast iron.

In general the consumption of lance per foot bored lies in the region of between 6 and 7 feet, but this may increase or decrease according to the silica content of the material being bored. The formation of iron silicate increases the fluidity of the slag and therefore the higher the silica content of the material being bored, the greater is the success and speed of operation.

The diameter of hole produced can be varied by employing lances of different diameters. For general purposes a lance of $\frac{3}{8}$ in. bore steel tubing is recommended which produces a bore hole of 2 to 3 inches in diameter according to the formation being bored. The speed of penetration is in the region of $1\frac{1}{2}$ to 2 minutes per foot for which approximately 6 to 7 feet of lance and 23 cu. ft of oxygen is consumed. Larger diameter single holes can be produced up to four inches diameter by increasing the size of lance tubing.

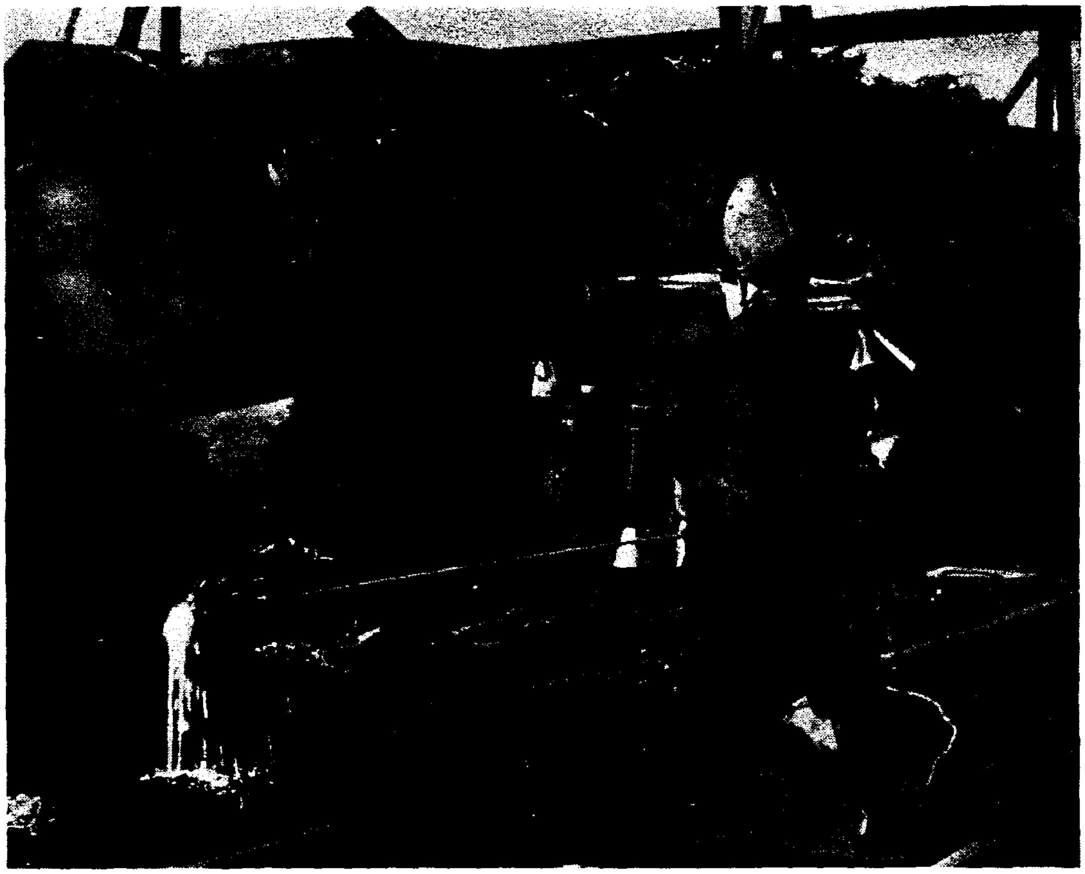

Fig. 4—Thermic Boring a Strong Room using a Sheet Metal Shield

Fig. 5—Oxygen Lancing Heavy Scrap Metal, the Operator being in Protective Clothing

Holes can be bored horizontally, penetrating up to 15 to 20 ft without difficulty. It is, however, advantageous, after approximately 5 ft, that the hole should be slightly inclined, rising at 5 or 10 degrees in the direction of penetration, to allow a free flow of the slag created so as to produce a uniform bore hole with the greatest possible speed of penetration.

Vertical boring can be carried out as well as horizontal boring, but in this case the consumption of both lance and oxygen will be higher. This is due to the fact that the oxygen pressure for vertical boring must be sufficient to lift the slag clear of the hole and failure to effect this clearance will result in wastage of the lance barrel. It is often advantageous to employ a larger bore for the first part of the operation to facilitate slag removal. In addition, there are one or two practical difficulties which arise when boring in this direction, such as manipulation of a long lance with the oxygen valve high above the operator, and the matter of operator protection from the heat generated. These, of course, can be overcome by means of suitable stands and shields, etc., similar to the set-up in FIG. 3, but for ease of operation and to assist slag clearance when boring deep holes, lancing in the horizontal plane is preferred.

It will be appreciated that in all boring operations, until complete penetration is achieved, the hot slag produced is expelled from the front. Some hot slag particles will be thrown forward several feet, the amount of which depends on the technique used and the nature of the material being lanced, as the reaction with certain materials is more violent than with others. The operator, therefore, will need some sort of protection. This can take the form of a simple shield, a piece of sheet metal having small holes through which the lance operates, as shown in FIG. 4 or protective clothing as illustrated in FIG. 5.

The hot slag produced also creates a fire hazard against which precautions would have to be taken where combustible materials are in the vicinity of the lancing operation. Sand and asbestos give protection from this danger.

It is not possible to give oxygen pressures for all types of work but, in general, these should be set slightly lower than those required for standard lance operations.

Typical operating data for two sizes of lance are shown in the following Table:—

SIZE PACKED LANCE (Nominal)	*OXYGEN PRESSURE (lb/sq in.)*	*OXYGEN CONSUMPTION (cu ft per hour)*
3/8 in.	60	660
	70	780
	80	860
	90	980
	100	1,100
	110	1,200
3/4 in.	60	1,100
	70	1,200
	80	1,300
	90	1,600
	100	1,700
	110	1,800

FIG. 6—CUTTING THROUGH SIX FEET OF CONCRETE

FIG. 7—REMOVING NEWLY CUT SLABS

Thermic Boring Under Water

This process can also be adapted for use under water but this operation requires special consideration, with particular regard to means of ignition. Work of this nature has been carried out by the Admiralty in this country and reports indicate that it is possible to drill vertically under water at high speed, as the slag produced becomes tempered and very friable under the cooling effect of the water. Experiments carried out in France show that a slab of concrete 12 ft under water can be drilled to a depth of 2 ft in ten minutes, and in reconstruction work on the foundations of the Albert Canal in Belgium, which had been badly damaged by bombing during the war, 27 large holes of 11 in. diameter and 51 cement injection holes 1½ in. in diameter were drilled by this method.

There are various methods of igniting the lance for under water work : it may be ignited on the surface in the normal manner and then be plunged into the water in accordance with the diver's instructions ; or it may be ignited electrically from a small battery under water, or by a cartridge, in which case the diver knocks the capped end of the tube on the surface of the concrete.

Applications of Thermic Boring of Concrete

Thermic boring is used fairly extensively in connection with the demolition of concrete structures, but because it is a more expensive process than pneumatic drilling for the normal run of work, its use, in the main, is restricted to reinforced concrete. As a rule it is used in conjunction with other tools, such as pneumatic drills, splitting tools, and the balling method (a heavy iron ball swung against, or dropped on to, the weakened concrete). Steel reinforcement in concrete, of course, facilitates the process and the thermic boring system is very often used when other drilling methods encounter such obstacles.

There are various occasions where thermic boring is employed exclusively, whatever the type of concrete in question. For instance, it is used when the noise of pneumatic drilling prohibits its use in work to be carried out near a hospital or where vibration from pneumatic drilling would have harmful effects on adjacent structures, and where expensive compressor plant is not available or is too costly to use for the work in hand. Thermic boring equipment is simple, inexpensive and highly mobile.

A case in point, where thermic boring was used exclusively to remove heavy sections of concrete is shown in FIGS. 6 and 7. Sections, measuring approximately 6 ft by 3 ft, were cut using a ¾ in. packed lance. Although thermic boring is primarily intended for boring, a cutting action can be produced by employing a large lance and a washing technique.

The result of the use of thermic boring to assist mechanical methods in breaking up a heavily reinforced concrete strong room are shown in FIGS. 4 and 8. Holes were bored at strategic points to cut through the reinforcement bars and to weaken the concrete using the minimum amount of materials.

Thermic boring has also been found a suitable method for making holes in existing structures for the purpose of passing piping, etc., through concrete floors and walls.

Some Other Applications of the Process

Apart from its use on concrete, thermic boring has also been used successfully by quarry engineers for forming blast holes. It has been found possible to drill holes at 4 in. per minute through freestone. Sandstone, providing the lime content is not too high, is ideal for the process.

Fig. 8—A Once Heavily Reinforced Concrete Strong Room broken up by Thermic Boring

Fig. 9—Lance, packed with Steel and Aluminium Rods boring through a Collapsed Mixer Bottom

Thermic boring has been employed to great advantage in getting back into operation collapsed furnaces and steel mixers in the minimum amount of time, and has also been used in the recovery of valuable scrap metal by breaking up furnace run-outs, etc. FIG. 3 shows the process being used to tackle a furnace bear weighing approximately 90 tons and consisting mainly of copper. The washing technique was employed to cut away sections of suitable size for remelting in the furnace.

It is possible to increase the temperature of the reaction by including a number of aluminium wires in the packing of the lance, usually in the order of 30 per cent or less, of the total amount. For many operations this boosting of the reaction is desirable but, on the other hand, the extra cost involved does not always warrant its use. Where the question of relative costs as compared with other methods is of primary importance, the extra speed of operation attained may be outweighed by the additional cost.

It is, however, a technique to adopt when speed is the most important consideration. Such an instance is shown in FIG. 9, where this system assisted considerably to get back into operation quickly a large steel mixer, the bottom of which had collapsed. As a result of this failure, the metal penetrated and mixed with the lining and tons of iron, magnetite and dolomite solidified in one huge mass. Before it could be removed through the comparatively small apertures in the side of the mixer it had to be cut into pieces 3 to 4 ft in width and depth.

It will be seen from the foregoing that while thermic boring is not likely to supersede conventional methods of breaking up concrete and other difficult materials it will always be available as an additional tool to be used under special circumstances or in certain emergencies.

The capital outlay to purchase the equipment necessary for thermic boring is negligible when compared to that required for pneumatic drilling.

THE POWDER LANCE

Powder lancing, a fairly recent development of the powder cutting process, provides a comparatively easy means of severing those materials which have hitherto proved impossible or uneconomical to cut by reason of size or refractory nature. It is also of considerable value to heavy steel foundries where it is used extensively for removing large sand cores which, during the casting operation, have become fused together with moulding wires and metal penetrated from the casting.

The principle of operation of the powder lance is similar to thermic boring except for the method in which the iron or iron and aluminium is fed to the reaction zone. In place of the packed lance, iron powder or a mixture of iron and aluminium powders is fed through $\frac{1}{4}$ in. gas barrel at a controlled rate of flow.

Equipment and Operating Procedure

This process requires the use of a powder dispenser unit whereby the quantity of powder flowing into the reaction zone in a given period of time can be varied by the operation of suitable controls. The one essential feature of any type of dispenser unit for powder lancing is the necessity for maintaining a constant rate of powder flow for any given set of conditions.

The powder dispenser, which is of the pneumatic injector type, is essentially a pressure vessel incorporating a hopper, air filter, air pressure regulator, dryer and injector unit.

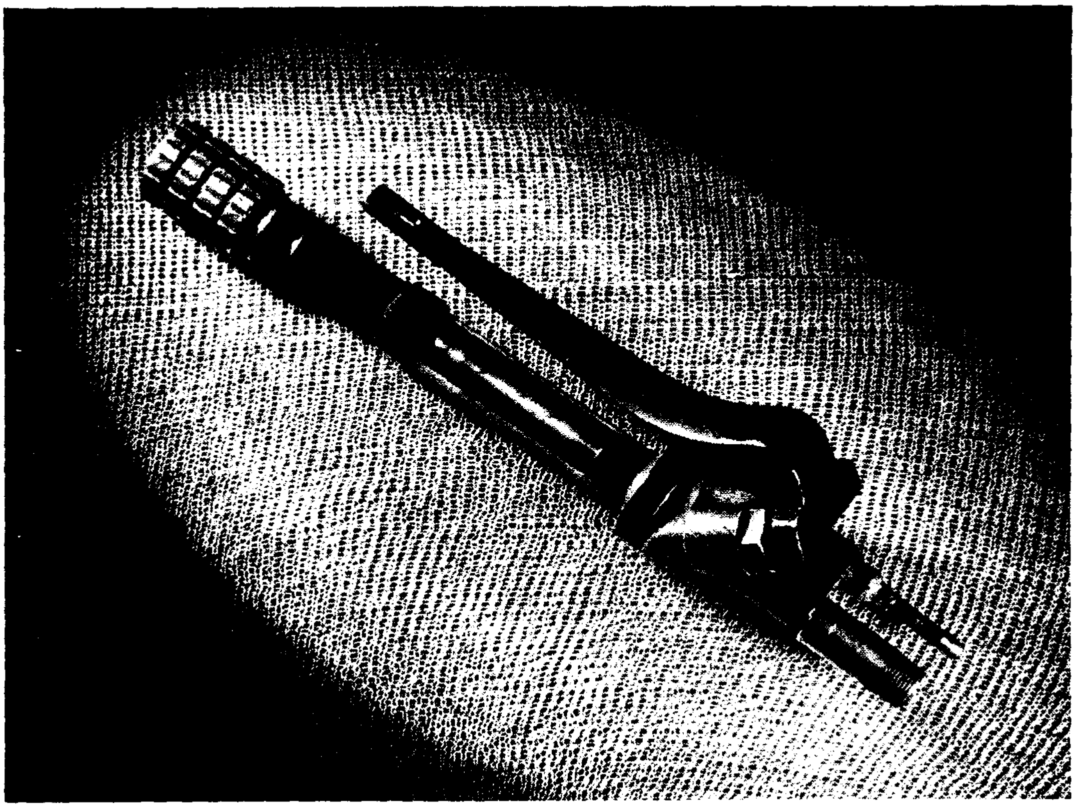

FIG. 10—POWDER LANCE HOLDER

Compressed air is fed through the dispenser and the powder is picked up b the air flow as it passes through the injector unit, the air/powder mixture bein carried from the dispenser to the lance holder by means of rubber tubing. Th special lance holder, as illustrated in FIG. 10, incorporates an injector and dual valve arrangement which is coupled to a high pressure oxygen suppl and the powder dispenser. The lever provided actuates the oxygen and powde valves in the correct sequence.

Operation of the lance is quite simple. Depression of the control lever cause the main oxygen stream to draw a variable flow of powder from the dispense conveying it through the lance pipe to the reaction zone. The lance pipe need no threading for fitting into the holder but ends should be dressed with a fil to ensure a good seat in the chuck. Failure to seat the pipe properly in th chuck may result in premature ignition of the lance within the holder due t friction caused by the high velocity particles of iron.

To begin operations, the dispenser is charged with finely divided iron powde or with a mixture of iron and aluminium powders, according to the type o material being lanced. Oxygen pressure will vary according to the application For example, when cutting non-ferrous metal or concrete, pressures require are in the region of 80 to 100 lb/sq in., whereas for washing out sand core from steel castings pressures may be as low as 50 lb/sq in.

As in the case of thermic boring the reaction is started by heating the lanc tip to red heat and opening the lever, whereupon the lance may be directed a the start of the cut. It is not necessary to heat a spot on the material to effec a start, although materials having a high thermal conductivity, such as coppe and bronze, will require some degree of preheat to effect maximum economy.

The lance must not be pressed into contact with the work face, but allowe to burn while maintaining a gap of approximately 2 in. between its tip and th

FIG. 11—POWDER LANCING A 30-TON BRONZE PROPELLER

face of the work. It is essential to confine the powder to the reaction zone and cutting on flat surfaces is best effected in a series of steps. The pipe is consumed at a low rate under correct conditions and this permits working with short manœuvrable lengths in difficult positions.

Applications of the Process

As a general rule, what has already been said about thermic boring with regard to the cutting and boring of concrete, etc., also applies to powder lancing. The use of powder, however, provides a more controllable lance, having a better washing action thus increasing the range of possible applications. With powder lancing it is possible to remove quickly accumulated slag from foundry ladles and converter lips and, as already stated, sand cores from castings without causing damage to the articles being treated.

Powder lancing has been employed when other methods have failed or would have been too expensive. For example, the cost of shipping a large bronze propeller to be broken up was cut considerably by employing the powder process to reduce its bulk at the dockside. The blades of the 30-ton propeller were removed and subsequent handling and transportation was greatly facilitated. The powder lance being used to remove the blades, which measured 12 in. at the thickest point, is shown in FIG. 11. Preheating was necessary and in this case was accomplished by a coke fire situated in the boss of the propeller. Once the blades had been removed it was possible to transport the propeller for the main part of its journey by railway.

Between them, the three processes described cover a wide range of applications and are playing an important part in industry today. It is not claimed that they replace any other method to any extent but rather that they increase the scope of present methods and may assist naval officers in their multifarious duties.