moulding a massive monument

by JOHN STEELE, M.I.B.F.

IN A PAPER* READ TO THE INSTITUTION OF PRODUCTION ENGINEERS (SOUTH AFRICAN COUNCIL) AND THE INSTITUTE OF BRITISH FOUNDRYMEN (SOUTH AFRICAN BRANCH)

A REPRESENTATIVE body of South African Jewry decided, in 1955, to erect a memorial in Johannesburg to the six million Jews who lost their lives in Europe during the Second World War. Sculptors throughout the world were invited to submit proposals for the monument. In 1956, the Johannesburg sculptor, Herman Wald, was awarded the commission for the design shown in fig. 1.

CREATION

Mr. Wald was on holiday, 700 miles from his studio, when he remembered that the closing date to submit an entry for the memorial was rapidly approaching.

Perspiration

Upon realising this fact, he decided to return to his studio and purchased a vast quantity of paper and crayons so that every moment, including the time on the train journey, could be usefully employed preparing material from which the ultimate design would emerge. Some two days, 700 miles and several reams of paper later, a dishevilled and frustrated man arrived at his studio, no nearer a solution than when he set out on the return journey.

Inspiration

This state of affairs existed until, one Saturday morning when, by way of relaxation, he decided to take a bus ride and buy the weekend family groceries. His purchases concluded, he commenced the return journey on a crowded bus amid jostling and parcel laden passengers. Suddenly *it* came, the vision! It was imperative that the idea be communicated to paper at once, and only then he discovered that he had neither pencil nor pad.

The urge, however, was so strong that ingenuity triumphed, and he frantically unearthed and unwrapped a portion of cheese from the bag of groceries and, with his thumbnail, inscribed the mental image on the humble dairy product. He scrambled out of the bus (with groceries and at the correct stop!), putting the finishing touches to the design as he hastily returned to the studio, where a more permanent substance could be used to record the creation.

A plaster of paris scale model (1 in. = 1 ft.) was made, bronze sprayed and photographed to illustrate the final appearance of the monument.

Interpretation

The sculptor's explanation of the design is that each of the main pieces represents one million dead. The hand is being thrust out of the ground in protest at what happened to them, and is holding aloft a ram's horn. This is the trumpet used to call the people together for worship and other ceremonial occasions.

The centre piece symbolises an eternal flame and is so designed that it vertically spells out the Hebrew characters for the sixth commandment: "Thou Shalt Not Kill."

The monument.

Preparation

The production of the foundry patterns occupied the sculptor for eight months and required almost two tons of plaster. The procedure to make a hand will now be described.

Firstly, a stout steel arbor was made to conform generally to the shape of the hand. This was blocked out in clay, which was worked on and modelled until the final form of the hand emerged.

The next stage was to obtain a negative from the clay model. This was made in plaster of paris and consisted of four pieces. Firstly, a ½ in. layer of coloured plaster (using red oxide) was applied to the face of the clay, followed by further applications of ordinary plaster until a total thickness of 2 in. surrounded the model. During this process, ½ in. steel reinforcing rods were embedded in the plaster to

"Massive Monument Made by Ancient and Modern Moulding Methods."

Model of plaster negatives with wax thickness shown on centre piece.

strengthen the pieces and prevent distortion. On completion, the pieces were removed from the clay model, the faces washed to remove all traces of clay and coated with a layer of shellac followed by a light application of olive oil. The pieces were re-assembled and tied together with rope preparatory to making the plaster positive which the foundry would use as a pattern.

Plaster was applied to the inner face of the corebox thus formed and, using hessian for reinforcing, was built up to a thickness of 2 in. On the completion of this operation, the rope was untied and the key negative removed. The remainder of the plaster was chipped away using a wooden chisel and mallet. The coloured plaster gave warning that the face of the model was near and the sculptor exercised extreme care to remove this without digging into the positive. The shellac and olive oil coating of the negative ensured a clean strip of plaster from plaster.

After checking the model for damage, any alterations were made, and the first pattern was ready for the foundry.

PRODUCTION

The manufacture of cast monuments and works of art dates from the very early ages. The current method of reproduction by the "Lost Wax" process remains, by and large unchanged. This point is demonstrated by the fact that the annual award presented by the International Foundry Committee, which is a reproduction of Cellini's "Perseus with the Head of Medusa" is made by the same method and materials used for the original by the sculptor in the 16th century.

A reasonably safe assumption is that the majority of such works are still made by the "Lost Wax" process, in which the sculptors have complete confidence and the foundrymen who practice the art, absolute faith. It is not surprising, therefore, that the sculptor's preference was to make this work by the same process, although, at an early stage in the discussions, the CO2 process was suggested.

The foundry concerned had never produced such a casting before, and certainly never used the "Lost Wax" process. Indeed, if an alternative title was required for this paper, it would aptly be: "From Sticks to Statues!"

The principal products of the foundry were and still are, chill cast bronze sticks. There is also a small jobbing non-ferrous foundry in which the heaviest casting made, before the monument, weighed 350 lb. and the largest moulding box measured 3 ft. 6 in. x 3ft. 6 in. The foundry floor measures 48 ft. x 57 ft. with a roof height of 20 ft., and at that time there were no crane handling facilities.

In the first instance, the management agreed to provide working space, tools, metal and melting equipment for experienced overseas personnel, who sub-contracted for the job, by the "Lost Wax" process. This arrangement was made because the directors had a personal interest in the memorial and wanted to insure that costs were kept to a minimum.

Although the moulding of the monument was orginally executed by the "Lost Wax" process, for reasons disclosed later, the bulk was completed using the CO2 process. For the sake of comparison between the two processes, the moulding of a hand will be described in each case.

FOUNDRY WORK: ANCIENT

The cramped area and dust laden atmosphere of the jobbing foundry were considered unsuitable, the preparatory work and moulding was therefore done in a small portion, measuring 30 ft. x 36 ft., of the company's metal store, and a pit dug in the foundry yard for the subsequent drying and casting.

Before moulding could commence, plaster negatives consisting of several pieces were made from each pattern supplied by the sculptor, thus forming a corebox which was used for the subsequent wax build-up and coremaking. The negatives were made by the same procedure as adopted by the sculptor, excepting for the fact, of course, that they were not chipped away from the model, but were carefully removed.

For ease of moulding and casting, the eternal flame was made in eight pieces, and no difficulty was experienced to produce this centre piece.

The hands, which were five feet high, were made separately, and the horn was made in four pieces. The part adjoining the hand was four feet long and three top portions measured three feet each. The actual opening at the top of the horn was 47 in x 21 in. (Total height 19'9")

Waxing

Each negative piece for the hand was prepared before applying the wax by rubbing a solution of oil and paraffin into the face with a soft cloth until all the pores were closed and an even polish attained throughout.

The wax preparation was made by boiling a mixture of paraffin-wax and bees-wax together to obtain a homogeneous substance. While still liquid, this mixeture was painted on the face of each plaster piece. When the wax was in a plastic state, it was kneaded by hand until it had a putty-like consistency, and a ½ in. layer applied to the previously painted surfaces. The thickness was checked at regular intervals with a depth gauge. When the wax build-up was complete, the pieces were assembled, set up in a vertical position and bound together with rope. The joints between the wax were sealed by the art moulder reaching inside the corebox thus formed and applying wax where required.

Coremaking

The moulding and coremaking material for this job consisted of 50 per cent plaster of paris and 50 per cent burnt clay grog with water added to form a creamy consistency.

The moulding material was made up in buckets as required applied to the internal wax face until a thickness $\frac{1}{2}$in. was achieved. Reinforcing rods were placed in the mixture during the application.

When the mixture had set hard enough, the entire corebox was inverted so that the core stood on its base. The rope binding the corebox together was untied and the pieces removed, leaving the wax on the plaster core.

Using a hot knife on the joints and any irregularities on the wax face, the surface was now smoothed over and the sculptor called in to check the wax positive, as this now represented the appearance of the ultimate casting.

Chaplets

At intervals of 18 in. over the surface of the model, flat headed nails were driven through the wax into the core until the head was flush with the wax face. The nails thus driven in, performed the same function as chaplets in a conventional mould by retaining the mould and core in the correct relationship to each other, after the wax had been run out.

Runner System

When the sculptor was satisfied with the wax detail, the runner system wat attached. This consisted of two main down gates on either side of the hand. These were made of cartridge paper formed into a roll $\frac{3}{4}$ in. diameter and coated with wax. A series of small $\frac{3}{8}$ in. diameter tentacle-like wax ingates radiated from the down gates to various points on the hand. Great care was taken in this operation to ensure that besides providing adequate metal to all parts of the mould, the wax ingates were placed at such an angle that all the wax would flow downwards out through the

Model partially sprued, showing wax thickness on core.

Moulder with pattern on drag box.

bottom of the main downgate during subsequent dewaxing. The use of a hotknife enabled wax to be sealed to wax.

Mould

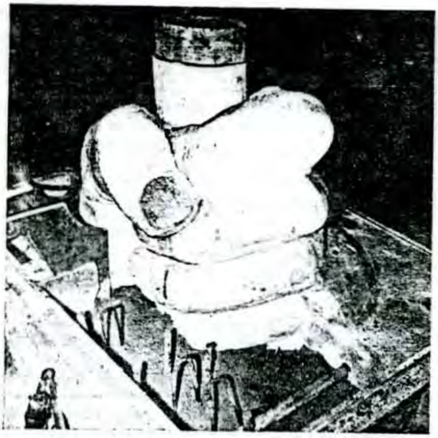
The refractory mix was again prepared in buckets as required and splashed on to the wax face in a similar manner to that used by moulders when watering a sand heap. The moulders worked at great speed during this operation in order that each course of plaster adhered to the previous one, until a thickness of 1$\frac{1}{2}$ in. to 2 in. surrounded the wax hand and runners. During the course of application, chicken mesh wire was wound around the mould to provide reinforcing which would prevent the mould from splitting during drying and casting.

Dewaxing and Drying

The mould was allowed to air-dry for several hours after which it was transferred by trolley to the foundry yard, lowered on to supporting bricks in the pit and surrounded by a temporary kiln, which formed its own flue. Starting with a slow wood fire in the bottom of the kiln and gradually increasing this until a steady heat was attained, a period of 10 days elapsed before the mould had been completely de-waxed and dried. The kiln was dismantled, all traces of the fire removed, the dewaxing holes stopped up and green sand rammed under the bottom of the mould. The mould was examined for cracks, which were sealed using the refractory mixture and dried with the latent heat in the mould. Steel plates were placed in position to form a box around the job and the gap between rammed with sand to stop any potential run-out. Prepared runner bushes made in the refractory mix were placed in position on top of the mould, sealed off and the mould weighted.

Melting and Casting

The metal used had the following analysis: Sn. 8-10 per cent; Zn 2 per cent; Pb 2 per cent; Cu balance. To calculate the weight of a casting made by this process, the art moulders weigh out the prepared amount of wax before



Corner drawback in process of being rammed.

use. When waxing is completed, the balance is weighed and this figure subtracted from the first weight. The result of this subtraction is the amount of wax used and this figure, depending on the specific gravity of the wax, is multiplied by a factor to determine the amount of metal required.

Originally, the metal was melted in seven different forced-draft, coke-fired pit furnaces and the crucibles carried individually to the mould and, by split-second timing, poured into the runner basin, one after another. Eventually, the metal was melted in two oil-fired tilting furnaces in which refined motor oil was the fuel. This has been proved to be equally effective, but less expensive than conventional fuel. The metal was tapped from these furnaces into hand shanks and carried to two geared ladles suspended from hand operated blocks and tackles erected for the occasion. When all the metal had been transferred, the slag was skimmed off, the ladles hoisted and the mould filled, a total weight of 2,000 lb. metal being used.

Fettling

Two days were allowed for cooling before the mould was broken away and the casting removed from the pit.

One of the problems experienced with the castings from the moulds thus made, was that, in spite of all care possible, they were extremely rough, with fins of metal inside and outside where the mould and core had cracked during firing. In addition to metal cost, this necessitated a considerable amount of extra fettling. This "chasing," to use a sculptural term, is done by hand, using hammer and chisel and is very time consuming. Indeed, speaking generally, from the results observed of some castings as taken from the moulds made by the "Lost Wax" process, the resultant works are masterpieces of the "chaser's" art!

Transition

In a period of seven months, only the eternal flame, one hand and part of the horn had been satisfactorily made. Several of the mould had leaked very badly and in others, due to the core having moved, there was no metal on one side, resulting in a disturbing number of the castings being a total loss.

The outcome of discussions between the monument committee and the foundry management on the subject was a decision by the latter to undertake the balance of the job by the CO_2 process.

The foundry was one of the pioneers in South Africa which adopted this process in its introductory stages. All sand cores for the hollow sticks, several dies for gravity die-casting and pattern plates, including one for shell moulding, were made by the CO_2 process. The decision was soon translated into action.

FOUNDRY WORK: MODERN

Preparation

A moulding pit 12 ft. x 12 ft. x 8 ft. deep was dug in the jobbing foundry. A pair of gantry rails erected over this and a second-hand, hand-operated travelling crane was installed. (This subsequently collapsed, but with no serious consequences, and was replaced by an electric unit.) Eight-foot by eight-foot cast iron moulding boxes were borrowed from another foundry, but as there was one short, a pattern was made and the box cast in four pieces (two sides and two ends) each weighing 850 lb., in bronze! This can be explained by the fact that the company also has a scrap metal business and it was cheaper to do the job than to buy it out. In any case, it was argued that eventually the box could be broken up and reclaimed. The cast iron boxes were only used to secure the mould for casting, wooden frames being used for the actual moulding.

A rotary type sand mixer was installed with a capacity of 150 lb. sand and a batch mixing time of 3 to 4 minutes. The sand used was mine-dump sand dried by the sun on the street pavement outside the foundry! A proprietary CO_2 binder was added in the proportion of 5 per cent to the moulding sand and 6 per cent to the core sand, which obtained 1 per cent of wood flour to assist in good break down after casting.

Greaseproof paper was used to permit easy withdrawal of the drawbacks, clean separation of vertical joints and prevention of moisture seepage from the clay thickness when making the core.

The metal section was determined by a clay thickness prepared using standard potter's clay mixed with water and flattened out to the required depth.

The method of moulding decided upon was the drawback system as this was admirably suited for all parts and common equipment could be used throughout. The original plasters made by the sculptor were used as patterns.

Mould

The drag box was set in the bottom of the moulding pit, rammed up and struck off level. The pattern was lowered on to this bed and accurately set on a vertical plane, at right angles to the bed.

The bottom joint was faced with greaseproof paper and the specially constructed moulding box placed in position for the first drawback, which measured 6 ft. 6 in. x 2 ft. 4 in. x 1 ft. 6 in. deep. Cast-iron grids (cast in an outside foundry), with lifters, were set in each drawback.

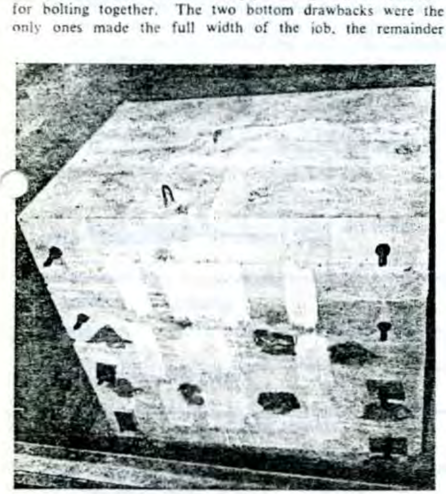
After a few courses had been rammed, a 2 in. diameter runner stick was positioned in one corner of the box and as ramming of the subsequent drawbacks progress, three 5 in x ½ in. ingates were set to run tangentially into the mould at intervals of 18 in. above each other on the downgate. This was repeated on the other bottom drawback, thus providing two downgates, diagonally opposite each other and a total of six ingates.

When the first drawback had been rammed to the halfway mark, two 1½ in. I.D. pipes were laid horizontally on the sand 9 in. from each end. When the drawback on the other side of the job was rammed up, two pipes were laid in exactly the same position, thus forming two parallel holes across the width of the job. One-and-a-quarter inch diameter bolts 5 ft. 8 in. long were then set into these holes and the drawbacks bolted together to prevent any movement during ramming of the mould, the core and subsequent casting.

On completion of the ramming and finishing operation on this first drawback, the top of the lifters were exposed and the holes filled with green sand. Holes were pierced at intervals of 9 in. through the side, provision having been made in the wooden moulding frame for this purpose. CO2 gas was introduced direct from the cylinder into the sand. Pressure gauges were originally used but blocking occured frequently due to freezing taking place, and this was eliminated by applying the pressure direct from the cylinder, control being exercised on the outlet valve. The average gassing time for this size of drawback was ten minutes.

After gassing, the wooden framework was removed and the vertical joint of the drawback trimmed and lined with greaseproof paper. The frame was then reset on the opposite side of the mould and the previous procedure repeated.

With both bottom drawbacks completed, the frame was raised, supported on wooden stays and the balance of the drawbacks made, in each case, pipes being laid in as before for bolting together. The two bottom drawbacks were the only ones made the full width of the job, the remainder



Complete mould assembly preparatory to breakdown for removal of pattern.

Core partly exposed (with thickness strips showing) as drawbacks are removed.

were made only half the width, thus making four quarters to a course. As there were undercuts at the thumb and small finger, separate drawbacks were made to cater for this, and the total number of drawbacks required for the hand was twelve.

Core

On completion of the drawbacks they were marked, withdrawn in turn and set aside. The pattern was removed and the bottom joint checked before the two bottom drawbacks were returned to their original position and bolted together. The ½ in. clay thickness was prepared and used to line the walls of the drawbacks, using greaseproof paper on either side to prevent moisture absorption by the sand.

During ramming of the core, coke lumps were placed in the centre and as ramming progressed, the drawbacks were returned to position, bolted together and clay-lined.

The core was rammed to the top level of the drawbacks then gassed down the centre. The drawbacks were withdrawn once more and the clay thickness removed. The entire face of the mould and core was cleaned off and painted with a spirit based mould dressing of the fired type and this imparted an excellent finish to the casting.

Closing

The mould was reassembled and the gap between the mould and core covered over with a layer of copper foil preparatory to the ramming of the top.

A special top box of lightweight construction (using aluminium cross bars), was fabricated. With this box in position, two flow offs were set in predetermined positions on top of the copper foil. These measured 3 in. x 1in. Due to the copper foil covering the metal cavity, there was no need to remove the top box after ramming with CO2 sand and gassing. Runner basins were made up for the two downgates, riser bushes for the flow offs and the job weighted down.

The 8 ft. x 8ft. moulding boxes were built around the in the "Lost Wax" process and placing of greaseproof paper in the CO_2 method.

In Table I an effort has been made to set out the principal operations performed when making the hand by both processes.

It will be noted that the number of operations performed only differ by one. In the "Lost Wax" process, the handling of the mould was a major consideration as there was always the danger of disturbing the relationship of the mould to the core, and this did in fact happen, but as the mould was entirely closed, this was not evident until the casting was removed from the mould and found to be a waster. In the CO_2 process there was also considerable handling of the drawbacks, but they were extremely robust and no damage resulted. Furthermore, the mould was examined thoroughly before closing and any defects were made good.

Table II summarises in tabular form the type of castnigs obtained from each process, besides providing a comparison of the labour used and time taken, again for the hand only.

In a work of this nature (while not denying the economics of the case) irrespective of the method used and the time taken, the surface finish of the castings and their likeness to the sculptor's original are considered to be the most important factors.

In this particular instance, the surface finish of castings obtained from the CO_2 process moulds was superior in the "as cast" state to that obtained after many hours of "chasing" of the castings from the "Lost Wax" moulds. They also bore a closer resemblance to the sculptor's original.

To the best of our knowledge this is the largest monument ever made in Johannesburg—and certainly the first of this magnitude made by the CO_2 process in South Africa. The majority of the works of art made in this country are executed by the "Lost Wax" process and some South African sculptors still send their works overseas for casting. The facts given in this paper may assist in changing this position.

This paper has been prepared firstly to record the production of this work; secondly to prove that the CO_2 process is a practical proposition for art moulding of this nature in particular, and in general, for the moulding of large castings. Lastly, and by no means least, to publicise the type of work undertaken by a South African foundry, with little knowledge, few facilities, but the determination to see the job through.

This is typical of the spirit of the South African foundry industry, and if this fact alone is widely published, the preparation of this paper will be justified.

ACKNOWLEDGMENT

Thanks must be recorded to the directors of Denver Metal Works (Pty.) Ltd., for permission to publish this paper and to their staff for the information so readily given at all times.

RESUMÉ OF DISCUSSIONS

INSTITUTION OF PRODUCTION ENGINEERS

Chairman: Mr. T. H. HUNTER, President.

MR. HUNTER: It is my firm opinion that this paper can be judged on its presentation and also the method and factual matter that has been presented to us tonight. There has been a fair amount of descriptive matter, the most descriptive matter, I think, that I have seen in any paper. The author has not adhered rigidly to the reading of the paper, but has described the process so clearly by his models that every one of us, production engineers and laymen, have learned a great deal. I am sure that I speak on behalf of the members of our Council, when I thank him for the presentation. I would also like to thank Mr. Pidermann for his CO_2 demonstration, and Mr. Pinker, who assisted Mr. Steele with the models. I am now pleased to announce that Professor R. Bain, Principal of the School of Art, Witwatersrand Technical College, Johannesburg, has agreed to make a contribution.

PROF. BAIN: I found Mr. Steele's lecture very interesting and particularly the demonstrations and exhibits which I think was a very practical idea. I have worked with the "Waste Wax" process, being a sculptor, and I have also spent much time in the foundry. I spent quite some time in the foundries of Florence where the great Cellini made his "Perseus and Medusa." I agree with Mr. Steele, although he arrives at it visually, perhaps over this monument and others, that the castings as taken from a "Waste Wax" mould, normally require a considerable amount of chasing. Even those days in the Renaissance, the "Waste Wax" process was not as good as it is today. It was not done by the same method, as is employed today, but they built up a model in sand and plaster more or less like the original, then they scraped back to what they thought was a reasonable thickness for the metal. Over this core they remodelled the whole work in wax and one can understand, of course, that in the process of modelling in wax (which took some time in a big monument), the artist would change his mind here and there, and other people would change his mind for him, and it was no trouble for him to add a couple of inches of wax here for a bit of drapery or change the nose or put a crown on, etc.

During the war I was rather fortunate in being sent on a private commission to Italy, and I had the opportunity of viewing dozens of the old masters for the first time in history on the ground level. They were underground in Florence for safe keeping. I therefore had the opportunity of seeing the inside as well as the outside and I can tell you, that they varied as much as from 1 in. to 6 in. in metal thickness. There was enough metal to cast three or four statues. Consequently, when they made the outer mould, more or less as they do it here, and cast the metal, they were practically pouring from one crucible into another and the metal remained molten for such a considerable time that it consumed the surface of the mould. When they broke off the mould, they were left with something that approximated the shape of the work. That gave rise to a school of engravers, from which today we get the beautiful Florentine engraving, it having become a tradition over these four or five hundred years. They are the finest in the world. The sculptors had to employ dozens and dozens of engravers, not for weeks, not for months, but for years.

It took Ghiberti 27 years to execute one of the Gates of Paradise (Baptistry doors), and 25 years for the other. I made doors not quite so intricate in modelling (they were three-quarter ton each leaf), for the Reserve Bank, Port Elizabeth, and they were cast and completed in a few weeks. They were 12 ft. 6 in. high. The reason for the length of time over Ghiberti's work was of course that they were chiselling all the time, day after day, year after year. He was of course engaged on other large commissions whilst his engravers laboured continuously under his supervision. They were not bronze castings, they were bronze carvings. That is why one talks about the delicacy of this so-called gronze casting of the Renaissance period, not because of delicate casting, but the beauty of the carved metal. Metal takes a beautiful cut.

Donathello was the first to discover how to make a good casting from the mould with a uniform thickness. He discovered it by accident when he was doing the great statue of St. Ludovico or St. Louis in Or. It was plated in gold and in order to plate this 14 ft. high statue, he had to work out a method of firing it in the kiln in separate pieces so that they could lie horizontal and, therefore, take a fairly even surface of gold. This sculptor arrived at the method of making sheets of wax to take the shape. By using this method of sheet wax and casting in bronze, he found that he obtained an almost perfect casting. I do believe, however, that the Ancient Greeks were much better at statue casting than the sculptors during this period.

I have seen works from the pre-Christian Era, by the "Waste Wax" process, and the castings are practically straight from the mould.

Donathello, on account of having discovered this method of sheet wax application and the resultant high quality castings, was the first artist to employ "leaving" the work, as it came from the mould, and cleaning it up where he wanted it. In other words, he used textures in art for the first time. This, of course, was a great advance in art with regard to metal casting, whereby one obtained, from the mould, the desired surface. Hitherto, in that particular period, over 200 years, the only surface obtainable, was from the chisel and hammer, etc. I would like to compliment Mr. Steele on his comparison between what, in essence, is a bronze carving and perfect casting, and I am all for perfect casting.

I would like to ask a question concerning the "Lost Wax" process: You mention that to harness the core in realtion to the mould, nails were driven in to the surface of the wax. Why was this practice adopted?

MR. STEELE: The reason for this was to maintain the relationship of the mould and core constant, but it did not in effect harness the one to the other. I suspect that Prof. Bain has in mind the conventional procedure with wax moulds, whereby the heads of the nails project beyond the surface of the wax and are subsequently embedded in the mould, thus tying the one to the other.

PROF. BAIN: Yes, that was the method I had in mind, and was the procedure we followed when I worked in art foundries, mostly in Italy. We always left quite a considerable amount of nail projecting so that the outer mould surrounded the head. This of course, had an added advantage in that you did not have the head of the nail on the surface of the casting, but only the stem.

MR. HAMM: How did you determine the height of each drawback and where the joint line would be made?

MR. STEELE: Before the moulder commenced moulding, the pattern was examined from every angle and the skill of the moulder enabled him to determine which plane would draw best in each direction, and the actual pattern was then marked in pencil to indicate the joint lines. As moulding progressed, the drawbacks were only taken to those marks and the joints made accordingly.

MR. TARDREW: Did you use a facing sand during the moulding?

MR. STEELE: In the early stages a fine silica sand of 200 mesh was used as a facing material, but this was found to be unnecessary as the spirit-based mould dressing imparted a satisfactory surface finish on the mine dump sand.

A speaker referred to certain works of art in Pretoria which had been made by the "Lost Wax" process, and, to the best of his knowledge, no difficulty was experienced.

MR. STEELE: I would like to make it clear at this point that, I am not denouncing the "Lost Wax" process for the reproduction of works of art and the ones referred to in Pretoria, namely the Louis Botha statue and Voortrekker woman at the Voortrekker Monument, are fine examples of works which have been produced in this country by a foundry which operates the process as a family tradition. Under normal circumstances, in an art foundry, this particular monument would most probably have been made in a dry-sand mould, using the drawback system. I should say, of course, that no novelty is claimed for the method of making this monument discussed in the lecture, but a certain amount of originality is claimed due to the fact that it has been made by the CO_2 process and I venture to suggest that it is not unlikely that to date this is the largest monument made in the world by the CO_2 process.

MR. CRAMPTON: I was associated with the monument in the early stages and it is my opinion that the failures in the "Lost Wax" process may have been due to the fact that the artisans were over anxious to provide sufficient metal to all parts of the mould during casting in order to produce a sound piece. I do think that it is possible the mould moved instead of the core due to the pressure set up during casting and the mould was unable to withstand the strain imposed by all the ingates.

MR. ARBUCKLE: With the casting of four separate pieces to form one complete Hand and Horn, did you experience difficulty due to the castings contracting differently, or was the contraction consistent? My own experience of the average casting is that they do not always come out exactly the same.

MR. STEELE: Contraction is constant in all directions proportional to the size, in other words, assuming the contraction in this particular instance was 2½ per cent, then the Hand which was 5 ft. wide at one point would contract 2½ per cent of 5 ft. and at the smallest portion of the Horn, about 18 in., the contraction was 2½ per cent of that dimension. The castings from the CO_2 mould required no dressing for assembly. Concerning your observation about castings in general not always being dimensionally consistent; this is, of course, rather a generalisation, but if a casting is made by the green sand method on the jobbing floor, the moulder may not always rap the pattern to the same degree. It is thus, therefore, possible for the mould cavity to be larger or smaller depending on the amount of rapping given to the pattern. This position can be further aggravated with the dry-sand moulding method as there is always the tendency for the mould to distort during drying. With machine moulding, however, in green sand, the problem is largely eliminated as the mould is withdrawn from the pattern plate in the same direction every time, at the same speed and, during withdrawal, a constant vibration is applied to the pattern plate. This point brings out the advantage of the CO_2 moulding method, as, by this means, the mould is gassed with the pattern in position, and when the latter is withdrawn, the cavity is an exact reproduction in the negative of the pattern form and dimensions.

MR. HAMM: You mentioned, Mr. Steele, that to support the six main pieces you utilised rolled steel joists in the centre, I would be interested to know from Prof. Bain how the ancient monuments were supported?

PROF. BAIN: First of all, they did not have a design of the nature of this monument which has a considerable overhang and is in the form of a modern structural piece requiring a tremendous amount of anchorage. The type of work done by the old masters, were mostly vertical, and almost self-supporting. The only anchorage they required was to the building when they were on pedestals as they had to be anchored to the building with the usual iron through the back embedded in to the stonework. The support of this structure is really an engineering problem. As a matter of interest, there are various methods of joining the pieces of statuary together. Donathello was probably the most in-ius, he used a variety of methods, one of which necessitated the making of wedged shapes which fitted into one another, and pouring metal into the wedge shape. Another method he used particularly in the statue of St. Louis, was to have the drapery overhanging and jointing the statue at those portions with screws, etc.,, through the back.

MR. KRINSKY: I recently visited Washington's National Art Gallery, where I was amazed to see some magnificent sculptural castings in bronze—every hair of the head, expression of the eyes and face were faithfully reproduced, that I am sure there could have been no carving or chiselling. I was particularly impressed by Bernini's "David and Goliath."

PROF. BAIN: Bernini was a much later period, about 250 years after Cellini, and in Bernini's day it was the age of high baroque, mid 18th century, and all "Lost Wax" castings were considerably improved by then. In this era they did know how to cast a uniform thickness of metal, but I doubt if there was no chiselling. The castings were so bad in the Middle Ages that it gave rise to a complete new profession, of chisellers. When the bronze founder had finished a casting, it was handed over to these craftsmen, who ied on with the carving and knew exactly what was wanted. I must make it clear, of course, that this engraving is not like fettling, where you knock a little bit off here and there in a haphazard fashion. The artisan who has served his apprenticeship as an engraver makes most of his own tools, such as an eye-making tool, a hair-making tool, they even fit eyelids and fingernails—they literally have hundreds of tools which enable them to tackle any problem which may arise.

MR. HUNTER: With regard to the engineering aspect, I understand that the CO_2 process can be used in conjunction with the Shaw process and that stamping dies can be made with this combination. Have you any experience of this medium of moulding? I would also like to know how South African foundries compare in their adoption of the CO_2 process judged by the European Continent, the U.S.A. and and the United Kingdom.

MR. STEELE: You are correct, Mr. Hunter, that it is possible to use the CO_2 process in conjunction with the Shaw process. The Shaw process, as you are no doubt aware, is based on a refractory mix with expensive ethyl silicate as the binder. The process has proved to be admirable from the point of view of faithful reproduction of detail and dimensional accuracy, but the expensive moulding material has tended to limit the application in this country. Development within the last two years, however, had been on the lines of a composite mould, whereby the Shaw process is utilised for the working face and the CO_2 for backing up, and forming the sides and top. This procedure obtains the benefits of the Shaw process while reducing the amount of expensive material required and the use of CO_2 bonded sand enables the casting to be produced more economically. With this type of mould it is possible to make stamping, die casting and extrusion dies, etc.

In reply to your second question, it is probably quite correct to say that South Africa is as advanced with the CO_2 process as any country in the world and I do believe that there are a higher proportion of foundries using the process here than in any other country, and a safe percentage would be 90 per cent. Mr. Pidermann, who recently returned from overseas, commented on the fact that he had not learned anything new about the CO_2 process, but in actual fact, was surprised to learn how far advanced the South African foundries were in their adoption of the process and development of new techniques. This is no doubt due to the inherent ingenuity of the South African foundryman who very often is confronted with an order for a breakdown or replacement casting, of which there is only one or a few required. More often than not he does not have the correct equipment for the job, and, on occasions, not even the experience necessary but, what he is lacking in those directions, is more than made up for in his willingness and ability to "give it a go."

MR. PIDERMANN: I would like to support Mr. Steele in his reply. Up until comparatively recently, figures obtained for the United Kingdom and South Africa show that on a pro rata basis, there is more of the CO_2 process used in this country than in the U.K. I am pleased that Mr. Steele mentioned the point that my overseas visit proved to me at any rate that South Africa was not lagging behind in this field and, indeed, it was my privilege, while overseas, to introduce methods in at least two foundries, which were considered routine in local foundries where the CO_2 process was utilised.

MR. VAN ROOYEN: The author mentioned that grease-proof paper was used as a parting medium between the mould and core during the ramming of this monument. Did not the crinkling of this paper impair the surface detail of the mould?

MR. STEELE: The mould was hardened before the grease-proof paper and clay thickness was applied and, although crinkling did take place, this did not in any way damage the mould face and the small amount of crinkling on the inner core surface, did not have any ill effect as this was, of course, the internal surface of the casting.

MR. MACLAREN: Was any parting powder or separating medium used to prevent the sand from sticking to the plaster of paris pattern used for moulding?

MR. STEELE: The sculptor's patterns had been made some seven months previous to their being used as patterns for the CO_2 process. They were, therefore, perfectly dry, and the plaster surface itself tends to have a powdery effect, which ensures a clean strip. No parting powder or other media was used, and the drawbacks came away clean from the pattern.

MR. ARBUCKLE: Was it necessary to use rolled steel joists in the centre of the main pieces and what allowances have been made for the difference in expansion and contraction between the steel and the bronze?

MR. STEELE: Expert advice has been obtained on this erection problem and it has been calculated that the asbestos lining on the inner surface of the castings will compensate for any differential expansion. The rolled steel joists were considered essential because of the excessive overhang.

MR. MOGFORD (proposing the vote of thanks): Mr. Steele has presented a very fine paper indeed, and what has amazed me, is that, in a way, anyone else could have presented this paper, and it would have just been a paper. What Mr. Steele has done for the lay production engineers who do not know a great deal about foundry work, is to simplify the technicalities of his paper by putting in a tremendous amount of work into the preparation of the models which he has used, and I feel that it is almost possible there has been a greater amount of work involved in the preparation of all the models than in the actual literature of the paper itself. The interest shown in the paper has been proved by the animated discussion. I would also like to acknowledge our thanks to Professor Bain for his valuable contribution to the discussion.

INSTITUTE OF BRITISH FOUNDRYMEN

Chairman: Mr. R. C. CROSS, President.

MR. CROSS: I have pleasure in calling on Mr. Leo Theron, Lecturer in the School of Art, Pretoria Technical College, to open the discussion.

MR. THERON: At the Art School we do a limited amount of casting and modelling which we hope to develop as the Art School grows. We might in the future arrive at the stage where we may specialise in plaster and modelling. At the moment we train art teachers and commercial artists and the type of modelling we do is subsidiary to the other subjects but it is certainly possible that in the near future we will open a section for specialised modelling and casting, etc. for students who wish to enter the hazardous field of casting their models in metal. We are extremely glad to have attended this lecture tonight, and have the opportunity of asking questions about the possibility of producing our small cast products by this new method. We normally do not have any models greater than one foot high and up till now it has not been possible for us to produce our own castings by the "Lost Wax" process, as it is too complicated and if we request the job to be cast outside, it is too expensive. Would Mr. Steele give an indication of the outlay to equip ourselves for this modern method of moulding on a small scale?

MR. STEELE: Setting aside the question of melting the metal and considering the moulding only. I think it is agreed that the major expense in any work of art is the time involved for moulding and chasing, and an approximate purchase price for works of art up to say a life-sized bust weighing about 75 lbs., is 20s. per lb. of metal, whereas present-day prices of that metal to the purchaser are approximately 2s. per lb. The student is therefore paying approximately 18s. per lb. for labour overheads, profit, etc., which is quite natural as the foundry is in business to make profit. A small proportion of this 18s., of course, is devoted to the moulding materials, fuel, etc. If, however, the art student could do that work and hand the subsequent mould to the foundry for casting, then the cost would be considerably less. All that would be required from a capital outlay point of view would be the cost of a pressure regulator for the CO_2 gas, and this is in the region of £10. The CO_2 cylinder itself is on loan and the cost of gas is approximately 6d. per lb. and about 1 per cent of this is used for hardening. The sodium silicate binder, at the most will cost 6d. per lb. and of this, 5 per cent is the usual addition. Moulding sand may be ordinary mine dump sand, properly dried, with the binder being added, and the mixture can easily be prepared by hand. It is perfectly feasible for an art student to prepare his own mould, using the drawback system, as illustrated tonight. The students are, after all, familiar with the producion of piece moulds in plaster of paris and observe the necessity of joint lines to prevent undercutting.

MR. COOMBS: This is possibly the first paper of this type we have ever had in our branch and the author is to be complimented on his preparation and presentation. It was my pricilege and pleasure to see the making of many of the castings for this monument and I cannot tell you how unbelievably bads the castings were from "Lost Wax" moulds. The main problem with this process seems to be cracking of the moulds and I saw some castings with fins ½ in. thick. I well recall seven months after the job had commenced and they were still making "Lost Wax" castings, the managing director of this particular foundry dropped his cigar consumption from ten a day to 2! and shortly after the foundry had commenced the CO_2 process for the job, he was not only back to ten a day, but he offered me one also! I would like to reply partly to Mr. Theron and tell him that one of our members has recently made a bronze casting for a work of art in which he used a metal casting plaster. The mould was made in section in exactly the same way as described by the author tonight, but instead of working from a plaster reproduction of the work, three plaster drawbacks were taken straight from the sculptor's original clay model. This was of a horse and rider and was 3 ft. 6 in. high and the total time to make the mould and core was in the region of 20 hours. The wall thickness was also formed by using a layer of clay against the mould. I do feel that whereas the CO_2 process offers the best prospects for making bronze statues, for an Art School, this casting plaster method would have advantages as the students are accustomed to working with plaster and they could eventually develop to the CO_2 method for larger works.

MR. LOUBSER: This is one of the finest lectures I have ever attended as the amount of preparation required for the model-making of all the moulding processes and stages must have been considerable. I recently attended a lecture on the new Boeing aircraft which had the entire Boeing Organisation behind it, whereas this only had the author and the South African moulder behind it. Mr. Steele is to be congratulated on the fact that his demonstration has been clear enough for the foundryman, art student, sculptor and engineer to understand every detail of the production of this monument.

Was there any special metal treatment during melting and did you have any feeding other than two small flow-offs for the hand?

MR. STEELE: During melting conventional fluxing methods were used, and the metal was deoxidised before pouring. There was no feeding of the castings apart from the two flow offs.

A VISITOR: Was the greaseproof paper placed against the mould after hardening, and how was the clay applied to the mould? What time elapsed for drying after completion of the mould and core and before casting?

MR. STEELE: You are correct in assuming that the greaseproof paper was placed against the mould after hardening. The clay was rolled out to the required thickness in a similar fashion to that used by cooks when preparing pastry with a rolling pin. It was then cut into slabs of about 12 in. square and placed against the greaseproof paper on the mould and pressed against the face to follow the contour exactly. A further layer of greaseproof paper was then applied to the clay surface, thus providing a clean separation of the core from the thickness, and, as explained in the paper, this prevented any moisture absorption by the core and mould from the clay. There was no time lapse between gassing the top and casting. This is one of the great advantages of the CO_2 process as a mould can be rammed, gassed, the pattern withdrawn, closed and cast without any delay. It must be borne in mind that there is no moisture in a mould made by the CO_2 process as the sand is thoroughly dry to begin with, and at the most, there is less than ¼ per cent moisture in the CO_2 binder.

MR. PEERS: Probably the difficulties experienced with the "Lost Wax" process were due to lack of suitable material and limited knowledge of the process by the artisans employed. It would be unfair to say that fine works of art cannot be made by this process. There are many such works on record which have been executed in this fashion and they did not require a lot of fettling to bring them to that stage.

MR. STEELE: There was no lack of suitable materials, as the artisans were given carte blanche to purchase whatever was required, irrespective of the cost. Mr. Peers is correct, however, that the knowledge of the artisans was limited and their experience previously had been confined to much smaller works. I would, however, suggest that the CO_2 process was the only way to make this monument economically and satisfactorily from a surface finish and dimensional accuracy point of view. I tend to disagree with Mr. Peers on his comments regarding works of art made by the "Lost Wax" process and requiring a limited amount of fettling. I would be most surprised to learn that this was so as the foundryman, today, who practise this art surely have more experience than their predecessors, yet their castings require a considerable amount of chasing, necessitated through mould cracking and occasional wax boiling.

Only today I visited the Art School in Pretoria and discussed this question, and I can assure you that any sculptors or artists present tonight will unhappily confirm this point. I must, however, stress the fact that this is a simple casting by comparison with average artistic work and in this particular instance it was possible to withdraw each piece from the face of the casting without encountering difficult undercuts, and I agree that there are many works of art for which the process would not be suitable. If, however, I may be forgiven for quoting a personal illustration, I may say that I recently undertook as a challenge, to produce a casting by the CO_2 process from a model prepared by the sculptor as a rough idea for the purpose of obtaining a quotation from the foundryman. The model, which was about 18 in. high, was of the two life-sized impala which have now been erected outside the Witwatersrand University main gates, in Braamfontein, Johannesburg. Fifty hours were spent in making a 27 piece mould and a bronze casting was produced, thus proving that with time and patience, it is possible to produce art works from CO_2 moulds. Obviously, of course, there are instances where undercutting is of such a nature that it is necessary to revert to the "Lost Wax" process for those pieces only. Take, for instance, a life-sized bust. In general it is conceded that from 50-75 per cent of the surface will permit the withdrawal of drawbacks made by the CO_2 process. The nostril and ear cavities can, however, present a problem, which is overcome by blocking these portions out prior to moulding, and subsequently, by means of gelatine and wax, to reproduce a small CO_2 core, which is then positioned in the mould according to the block print. In this manner, one can take adventage of the flexivility of the "Lost Wax" process and retain the tremendous benefit of a complete CO_2 mould.

A VISITOR: How was the core retained in the correct relationship to the mould and how was it fixed to the drag? Was the core reinforced in any way?

MR. STEELE: The joint on the drag box was made in the form of a step which ensured the correct registration of the bottom drawbacks on the drag and to each other. The core was rammed as an integral part of the drag and was rigid enough to retain the relationship to the mould without the use of chaplets. No reinforcing was used in the core as, not only was this unnecessary (indeed the centre of the core was filled with coke), but any such reinforcing could have caused the metal to tear during contraction. The metal was only ¾ in. and the hand at its widest portion was 5 ft. across so that the danger of tearing was a very real one and all possible precautions were taken to avoid this trouble.

MR. GARCIN: When the "Lost Wax" process failed, due to the cracking of the mould material, would it not have been a practical proposition to use the CO_2 moulding material in conjunction with the "Lost Wax" method? I mean by that, that the CO_2 sand could have been rammed against the wax face to a given thickness, then gassed and the mould dewaxed in the conventional manner. This would have been a great timesaver as all the time spent in preparation of the drawbacks would have been saved. I have actually used this method myself for small models and I would like to know the reasons why this was not adopted.

MR. STEELE: The method was not even considered because of complete lack of confidence in the "Lost Wax" process. To follow the method suggested by Mr. Garcin may have saved time in the moulding operation as he suggests, but there would still have been the handling of the mould, firing for de-waxing, and the great disadvantage of being unable to examine the mould prior to casting.

MR. WILLIAMS: It is a pleasure to propose a vote of