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FOUNDRY TRADE JOURNAL

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Public Opinion

Mr. Richard McMillan, a war correspondent with the British troops in France, reported to his paper that "Caumont was seized after a forced night march. The streets looked like an ironfoundry, with shops and houses gaping wide open." This type of journalist if he ever did visit an ironfoundry would probably embellish his description with such expressions as "rivers of liquid fire debouching into gargantian cauldrons." "A robot incessantly gnawing into a mountain of sand made moulds for guns and tanks with incredible speed." The technician openly sneers at such "tripe," but these picturesque illusions do leave their impressions on the lay mind. Of the thousand or more foundries we have visited at home and abroad only a handful could be said to bear the faintest resemblance to a devastated region. To convey an adequate picture of the foundry industry to the layman is not easy, but it must be tackled. Otherwise the industry will fail to attract the labour necessary for its maintenance, let alone expansion. Some of the essential steps are obvious, such as the intensification of the "good housekeeping" propaganda within the industry. The emulation, by the largest foundries of the system inaugurated by the Ford Motor Car Company before the war of opening their works for a day or so every week for inspection by the public. The extensive use of propaganda films has much to commend it, especially if less attention is given to the sales angle and more to the human aspect. A film showing the work and life of an apprentice from his entry to his attaining full craftsmanship is urgently needed. Pictures showing him in the various laboratories, making cores and moulds, melting and handling liquid metal, attending lectures, and so forth, would quickly eradicate the distorted impressions now prevalent.

We are satisfied that so far as scientific, engineering and metallurgical interests are concerned, the foundry industry is well on the way towards establishing itself in its true perspective. Colonel Blimp, who in an important committee during the earlier stages of the war, roundly condemned cast iron as an engineering material on the grounds of personal experience with a faulty domestic boiler is now rightly ignored. The hard core of the general population still remains ignorant of normal modern conditions, and it is this very large mass of people that is being doped with skilful propaganda as to the merits of the products of rival industries. No thought is given to the fact that these newer industries have to rely on the foundry for the creation of its manufacturing plant, its presses, its dies, its moulds, its transport, its prime movers, and so forth. The fundamental nature of the foundry industry needs constantly to be in the minds of its protagonists. From the days of Tubal Cain until the advent of Bessemer and Siemens the founder enjoyed an exceptionally elevated place in society. Denbenvenuto Cellini held a unique position in the courts of Europe, the gun founders of Sussex were people of the highest importance in their day, whilst later Wilkinson was a real factor in international armament.

With the advent of steel, the ironfoundry lost much of its former industrial glamour. Now light alloys and plastics have captured the public imagination, and both iron and steel makers will have to do much to preserve a balanced perspective in the minds of the layman. That both iron and steel are taken for granted is not enough. There must be a forward policy. If a child prefers a new toy, interest in an old one can be restored by repainting or redressing it. There is much to be done in repainting and redressing iron and steel products for a generation that has been brought up in an atmosphere which gives credence to the notion "if it is new it must necessarily be better."

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FOUNDRY INQUEST—VIII

By "Coroner"

Numerous examples of defects from gas-holes can be traced to the over-carefulness of the moulder. One particular example, shown in Fig. 1, was continually giving trouble, and the core-making was suspected and a careful watch was made on their manufacture and drying. This part of the work appeared satisfactory, but still wasters occurred. The real cause of the trouble was then found to lie with the moulder assembling the cores. A vent channel had been made

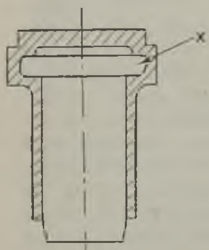

FIG. 1.

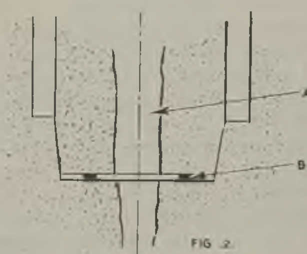

FIG. 2.

in the core to facilitate the removal of the gases from around the neck portion (X, Fig. 1) and, fearing entry of metal into this channel, the moulder filled it with sand, thus blocking the free exit of the gases, which consequently gave trouble. The correct method of overcoming the entry of metal to the vents was to make the core-print a little deeper than required and place a ring of loam around the vent hole and press tightly into the print, the position of the core being tested by a gauge on the top. Fig. 2 shows the arrangement, A being the vent, B the ring of loam.

COUNCIL OF IRONFOUNDRY ASSOCIATIONS

Proprietors of firms who have not yet sent in their return to the questionnaire on post-war reconstruction are earnestly requested to do so without further delay. The time is approaching when the report based on these returns will have to be made by the C.F.A. In order that this report should be as complete as possible and should represent the greatest possible proportion of the tonnage produced by ironfoundries, it is essential that the answers to the questionnaire be received by the secretary of the C.F.A., and arrangements are being made to deal with all returns during the first half of July.

Mr. F. C. Williams, the first hon. secretary of the South African Branch of the Institute of British Foundrymen, was a member of the delegation to the International Labour Conference recently held in Philadelphia.

OBITUARY

Mr. Walter Dodds, director and secretary of William Gray & Company, Limited, shipbuilders, West Hartlepool, died on June 15, at the age of 54.

Mr. Alexander Haxton, a director of David King & Sons, Limited, ironfounders, who was in charge of their Skipton foundry, has died at Skipton at the age of 62.

Mr. Edmund Bruce Ball, managing director of Glenfield & Kennedy, Limited, hydraulic engineers, Kilmarnock, has died, aged 71. He was president of the Institution of Mechanical Engineers, 1939-40.

Mr. Wm. Mitchell, of Paisley, died recently. He had been employed by Thos. White & Sons, Limited, ironfounders, for 37 years, and, for 25 years of that period, had been foreman in the foundry. He was a member of the Scottish Branch of the Institute of British Foundrymen.

Mr. Peter Forbes Jones, managing director of Jones & Campbell, Limited, Torwood Foundry, Larbert, died on June 17, aged 63. He was chairman of James Jones & Sons, Limited, colliery timber merchants, etc., of Larbert, Scottish Enamelling Company, Limited, and the Buckie Ship and Shipyard Company, Limited.

Mr. A. Lawrie died recently. Mr. Lawrie was president of the Scottish Branch of the Institute of British Foundrymen 1923-24, and had always taken a great interest in the work of the Institute in Scotland. He was, for many years, foundry manager with Andrew Strang & Company, Limited, Blair Foundry, Hurlford, Ayrshire.

Mr. Harold Morgan Williams, a director of John Williams & Sons (Cardiff), Limited, Globe Foundry, Cardiff, died on June 21, aged 61. He was a younger brother of Mr. Edward Williams, a past-president of the Institute of British Foundrymen. His son, Mr. H. J. V. Williams, is President of the Wales and Monmouth Branch of the I.B.F.

Lt.-Col. Lord Herbert Scott, who died at Winchester, was chairman of Rolls-Royce, Limited, and the Westinghouse Brake & Signal Company, Limited, and a director of the Consolidated Signal Company, Limited, and other companies. He was vice-president of the Association of British Chambers of Commerce. From 1934-35 he was president of the London Chamber of Commerce. From 1928-31 he was president of the London Chamber of Commerce, and from 1934-35, president of the Federation of British Industries. Lord Herbert Scott was 71 years of age.

INDEX TO VOL. 72

The Index to Vol. 72 of The Foundry Trade Journal, covering January to April, 1944, inclusive, can now be obtained, on written application, from the Publishers at 3, Amersham Road, High Wycombe, Bucks.

TOLERANCES AND INACCURACIES IN PHYSICS*

Importance of studying the principles of tolerances

By SIR CHARLES G. DARWIN
(Director, National Physical Laboratory)

The makers of almost any kind of mass-produced article are very familiar with all the troubles that arise in working to assigned tolerances in their manufacturing processes. I expect for the most part they regard it as a nuisance having to do so, and that in a properly regulated world it is the sort of thing that would have been left out. After all we none of us like dwelling on our own imperfections, so why, when we have said that we are going to make something an inch long, should we have to waste time over those little peccadillos which make it a few ten-thousandths wrong; or, when we plan to make an iron casting with 1 per cent. carbon, it is annoying if the properties turn out all wrong because we find we really had 1.05 per cent. of carbon. The physicist has been even worse in this neglect of thinking about tolerances, because he was always formulating exact laws, and then trying to verify them experimentally. Of course, he had errors in his experiments, but they were mostly just a nuisance, and he was usually not interested in them in themselves, but only as an impediment to the realisation of what he thought of as an absolute truth. For his purposes he was often quite right in this, but it led to a general outlook from which errors and tolerances were excluded.

Teachers were still worse in this respect. Just as our theological teachers will try and prescribe what will constitute perfect virtue, and will not devote much time to, shall we say, calibrating the various degrees of vice that are inherent in all human conduct, so the teacher in an engineering school has in the past tended to describe only perfection and not to give much attention to the faults which in fact always occur in manufacture. It might be said that teaching has tended to be entirely intolerant. I have for a good many years been interested in this neglect in our outlook, and I was frankly shocked only three or four years ago when I put it to the proof. I happened to be visiting a member of the staff of one of our leading engineering schools, and I asked him what the students were taught about tolerances. He looked a bit blank, and said: "I don't know; let's have those two boys back, who have just gone out, and ask them." So the students (who were second-year scholars) were called back, and I asked them the question of what the word "tolerance" meant. One simply did not know. The other gave the correct answer, but on cross-examination I found he was really cheating because he happened to be the son of a prominent industrial scientist and had learnt about it at home.

The main purpose of my lecture is to emphasize the point that tolerances have now become a respectable part not only of engineering practice, but also of fundamental science, and that a study of their principles can be a really interesting subject. You will naturally at once think of the great developments in the field of quality control of production that have been taking place in the last few years, but I am not going to discuss this aspect; to do so would involve going rather deeply into technical mathematics. I would only say that the point of it really is that, once you recognise that there are to be errors, you find that they do have very prevalently a certain distribution, so that large ones become rarer than small according to a rather well defined rule, and that you can exploit this rule so as to get a great deal more out of your measurements than you might expect to at first sight. The process is still in its infancy, and I have little doubt that improved methods of sampling will lead to considerable economies in the application. However, it falls outside my subject, because I intend to show that a great many interesting things can emerge merely from the idea that there will be errors, either of manufacture or of experiment.

I am going to illustrate the subject by giving a series of examples, starting with large things and working down by degrees to smaller and smaller things. I ought perhaps to apologise that none of my examples will have any very immediate relation to metallurgy or chemistry; the general principles apply there with equal force, but have not been so well worked out yet. But the outlook is the same, and it is one which should be much more familiar than it is, not only to engineers of all kinds, but also to everyone in every walk of life.

Examples from Human Affairs

My first example is with regard to whole numbers. Here is a case where you might think there could be no error. There are either 100 or 101 men in this room listening to me, and there cannot be both. But it is very likely that, when the number is large, someone will have come late and someone else will have to go early to catch a train, so what is the answer then? One interesting example of the tolerance of large numbers is the rate of accidents. They used to publish the number of people killed per year in motoring accidents. It used to be at a rate of about 500 a month. What fluctuation would be expected?

* The Edward Williams lecture delivered to the Forty-first Annual Meeting of the Institute of British Foundrymen.

Tolerances and Inaccuracies in Physics

The law of chance answers immediately, that it will be about the square root of this, that is to say 23, and that anything like a fluctuation of twice as much, say, 50, either way is distinctly unlikely. Notice that from this we can say with considerable confidence what is the safest month to live through; it is February, because that is three days short in 31, that is 10 per cent., so that there should on the average be 50 less killed, and this defect is very unlikely to be beaten by the chance fluctuation. But the statistician can go a great deal further than this. It will be easiest to see how he works if I put the story backwards. Imagine that we are not dealing with motor accidents, but with railway accidents and, to simplify, we will suppose for the moment that every train holds exactly 50 people, who are all killed when there is an accident. If there are again on the average 500 people killed a month, that means 10 accidents, but as the square root of 10 is about 3, the fluctuation will now be quite often 3 times 50, and so we shall in some months expect to see a number of 650 fatalities, which would be extremely unlikely for motoring accidents. I have, of course, over-simplified things, but you can see how an expert, being given a list of numbers for successive months, could from the magnitude of the fluctuations, and nothing else, get some idea of what was the cause.

Weighing Bullets

My next example is interesting to me personally, because it happened to be the thing which suggested to me about 12 years ago what an interesting subject in general this was—before that I had only thought about it in connection with ultimate physical theory. I happened to be visiting an engineering works where they were making a machine for Woolwich, which was to weigh bullets. The bullets were to be used for the testing of armour and a rather high accuracy was asked for. The machine was, I imagine, much like those used in the Mint for weighing coins, but as it had to handle a great many bullets, speed of operation was important. It worked like this. The bullets were pushed in a row along a groove. At one place each in turn came on to a balance with the proper counterpoise, and a lever freed the balance. If the bullet was right, the balance would stay level, and the next push would send it straight on. But if the bullet was too heavy or too light, the scale would fall or rise and the push would throw it out—I cannot remember the exact mechanism.

The question then is, how quick can the balance be made to work? Obviously, if a very close tolerance is needed, a bullet which is just to be rejected will only be a little wrong, and so will only tip the scale very sluggishly. I took a tolerance of one part in a thousand. It is a very straightforward problem in elementary mechanics, but I shall not inflict it on you. The point is that, with the given value of gravity, and with the inertia which the system must have because of the bullet itself and the counterpoise, one can easily see how long it will take to rise to a height of the diameter of the bullet. If one attempted to discriminate earlier than this time, the guide for the correct bullets would get in the way of the rejected ones. The answer came out that it really did not matter what one did, one could not weigh the bullets faster than about one a second. I ought to say that here, and in most of my subsequent argument, I am going to practise a type of arithmetic which has attractive features for most of us, because I do not pay any attention to mere things like hundred per cent. changes.

When therefore I say that you cannot do more than one a second, what I mean is that you might do two or you might possibly only be able to do one every two seconds, but that you certainly could not do ten a second, and certainly could easily do one in ten seconds.

The moral of this example is that it takes time to do a weighing, and that the more precise it is to be the longer it will take. It is easy, of course, to imagine machinery by which at the price of a good deal of complication I could speed up the process. For example, I might have a long boom projecting from the balance mid-way between two contacts which were rather close together. Then a much smaller motion of the balance than I took before (which was the diameter of the bullet) would show which way the scale was going, and I could imagine a grab coming out and knocking away the rejects. I do not say this would be a practical machine to make; indeed, it would certainly be simpler to make ten of the simple machines and work them more slowly, but the point is that we can imagine ways of speeding up the business beyond our first estimate. I mention this because later I am going to come to an absolute limit of time that is essential for weighing anything to any assigned accuracy.

Tolerances in Voice Production

My next example is from the theory of sound. Briefly, the question is this: A man sings a note: how long is it before I can say whether he was in tune? To define the experiment we might suppose that a tuning fork has been struck, and that he is trying to sing the same note. A musical note is a harmonic vibration, so that he is sending out a train of waves of a certain frequency, and so, too, is the fork. If he is out of tune his frequency will be a little wrong, which means that, whereas at first his maximum of air pressure was in step with that of the fork, after a certain number of cycles he will have got out of step. When a piano tuner wants to get two notes in tune together, he listens to the beats between them, and gauges the accuracy by the seldomness of the beats. He certainly needs to hear two or three beats before he can say if they are tuned, but we will be generous and imagine that a single beat would suffice. Thus we can only say the man is out of tune with the fork if there has been one beat between them, that is to say, if there is time for the man's sound wave to put in one more oscillation than the fork has done. Let us come to numbers. The man is to try and hit the C below middle C, and we will not criticise him if he is nearer to it than a semitone. This C has a frequency of about 120 cycles a second, and a semitone is about a twentieth in frequency. So we will pass anything between 114 and 126 as our tolerance. The difference of 6 cycles means that after a sixth of a second the man will have completed one cycle more or less than the fork, that is to say, that there will have been the one beat that we are looking for. So the answer is that the man can sing for a sixth of a second before we can find out that he is off the note by a semitone. A woman has a much harder time. Say she is singing the upper C. This has four times the frequency, and therefore a semitone, again a twentieth, is now 24 cycles different. She therefore gives herself away in a twenty-fourth of a second. It is very easy to verify what I have been saying. If you try and play a shake of a semitone on the piano, you will find that if you do it in the rather deep bass, the whole business seems to become meaningless. This is a matter of pure physics (though no doubt the character of the human ear reinforces the trouble), in that the notes struck are really indefinite, because each note is not given time to define itself.

Light Wavelengths

Next I am going to take an example from optics. It is the typical example of the idea of "resolving power," which was so well worked out by Rayleigh about 70 years ago. The principle is most important in connection with lenses, but there is a simpler case which gives the whole gist of it. When we want to use a mirror galvanometer for very sensitive measurements, we set the source of light and the observing telescope both a long way off, so that a very small deflection of the galvanometer needle gives a large motion of the image. At first sight it would be tempting to think that we could increase the sensitivity indefinitely by increasing the distance, but this is not so. For consider how the image is formed; we will suppose an appropriate lens is put somewhere in the path to focus the filament on a scale. The bright spot on the screen is at the place where all the rays from the lamp have exactly the same number of wavelengths to the screen for every point of the mirror. Now suppose the mirror turns a little, but think of the same place on the screen. We shall expect to detect the deflection when this point first goes dark. When will that be? The answer is, when the rays that go from the light *via* one edge of the mirror differ by about a wavelength from those that go *via* the other. The intermediate parts of the mirror will then give light in phases in between, and the whole lot will cancel out. Thus the smallest turning one can detect is when one edge of the mirror has advanced a wavelength compared with the other. It may happen to be convenient to do this by setting up the screen a long way off, but it is just as good to use a more powerful telescope to look at it from near by, or even as an extreme case, to take a microscope and watch the mirror edgewise itself, for a good microscope can detect just one wavelength of light. So the result that emerges is that it is the breadth of the mirror that matters and not the distance at which the screen is set up. From our present point of view we say that any measurement of a length is always subject to a tolerance of a wavelength of the light used in the measurement.

A wavelength of light is pretty short, but the principle that we cannot see detail smaller than a wavelength does not satisfy us, and we want to know whether the finer details cannot be observed in some other way. One obvious trick is to use a shorter wavelength, both by oil immersion and by using ultraviolet light. The electron microscope does the same sort of thing to a higher degree, and because it has attracted attention recently I might digress a little to say something about it, even though it will have no very direct bearing on my main subject.

Electron Microscope

Both types of microscope work on much the same principle. Let us suppose we want to study the shape of a small black dot. In either case we first must have a condenser to throw rays of light, or of electrons, on to the field of view. To get good resolution calls for a strong condenser, that is to say, rays coming in on to it over very wide angles. The ones that fall on the dot are stopped, but the rest go through, and the microscope lens focusses them on to a photographic plate—or possibly the focal plane may be viewed with an eyepiece. The lenses that bend the electrons are either electric or magnetic fields, without, of course, the sharp surfaces of glass lenses, but they work in much the same way and all the elementary formulæ of geometrical optics apply to them, including the ordinary relationships of distances and focal lengths to magnifications. As to the resolution, we have seen it depends for light on the wavelength, and we must ask what corresponds for the electron. It was only discovered about twenty years ago that this was a question that could be asked at all, but once recognised, the answer could be given. I fear it would take too long to discuss this properly, though, in fact, I shall presently be talking on the same subject from a different point of view, and the connection will not be very apparent. Here I can only say that the resolution is proportional to the voltage of the electrons, and for the voltages used, such as 60,000, it is about 10^{-8} cm. It looks as if we should be able to see single atoms, because that is known to be about their size. Unfortunately, there is a catch in it. The resolution of a microscope depends on the angles through which the rays are bent, and for the highest class of microscope the extreme angle should be nearly a right angle. This calls for a very elaborate lens system in order to correct the various optical aberrations and form a good image. No one has yet succeeded in correcting any of the aberrations of an electron lens at all (and theory suggests doubt as to whether it will ever be possible to do so to any considerable extent), so that in fact the rays

Tolerances and Inaccuracies in Physics

in the electron microscope can only be deflected less than a degree of arc, or the image becomes spoiled. The consequence of this is that a great deal of the resolving power is sacrificed, and the most hitherto gained over the optic microscope has been a factor of about 50 in magnification, instead of about 2,000, as simple consideration of wavelength might at first sight have suggested. One might hope to improve things by putting up the voltage, so as still further to shorten the wavelength, but another trouble then comes in, because the electrons pass so easily through the object that the image becomes too faint to see.

When we want to get down to seeing smaller sizes we know we need shorter wavelengths, and this suggests using X-rays. This has already been done long ago indirectly, and the great subject of X-ray crystallography has been the consequent development, but no one has yet made an X-ray lens; however, X-rays are exactly the same thing as light, and so we may legitimately imagine we could make a microscope for them. This would take us to about 10^{-9} cm. Allowing ourselves in imagination the same latitude, the gamma rays of radium would take us a good bit further, and after them we might imagine we could use the cosmic rays—perhaps with a little hesitation, because they are still rather mysterious. In this way we might suppose we could see things of the size of about 10^{-13} cm., and it might seem natural to ask what next. But the whole subject received a twist about 20 years ago in a different direction, and this I must now describe.

The Quantum Theory

During the first 25 years of this century the quantum theory was a disturber of the peace in the ideas we all had about ultimate mechanics. It was so obviously right and yet it so hopelessly contradicted all the laboriously compiled, and also obviously right, ideas of the older physics. The conflict between the two was increased about 1922 by an American physicist, Arthur Compton, who first propounded a theory and then verified it experimentally. His idea was this. He asked the question, what happens when a light wave passes over a free electron? The old answer would have been unhesitatingly, that it shakes it to and fro a little and in consequence the electron scatters a little of the light steadily all round. Not so, said Compton. According to the quantum theory, though light has wave properties, it also has qualities like a particle, and my guess, from general analogy with other parts of the quantum theory, is that this is a case where it will be like a particle. Therefore, when the light passes the electron, there will be a certain chance that they will behave like a pair of billiard balls, so that the electron will suddenly be thrown off in one direction, and the light will bounce off into another, as in billiards. To get a good large effect you must use a heavy light particle. Ordinary light is not heavy enough, but X-rays will be. So the experiment had to be done not with light, but with X-rays, and with these he brilliantly verified it. There are a great many interesting things about this effect, but I shall not go into them because the only one that I need is that when light passes over an electron, if the electron scatters the light, then the light also scatters the electron, that is to say, it gives it a flip in some direction. This flip is larger, the harder the X-rays, that is to say, the shorter their wavelength.

In the year 1926 the solution of the main contradictions between the old theories and the quantum theory was found. A number of people were concerned, but chief among them was a young German physicist, Heisenberg. At first the solution was in a rather abstract mathematical form, but it was not long before Heisenberg himself discovered a way of understanding it physically. He asked the question, what happens if you really start trying to decide where an electron is. You might go about it by making a microscope, but to get satisfactory precision you would take an X-ray microscope because of the short wavelength—true we do not know how to make one yet, but we can be reasonably satisfied that it is a legitimate thing to imagine. With this you look to see where the electron is, that is to say you shine X-rays on the electron, which scatters the light, and this scattered light you then focus in the microscope and look at the image. But now comes the catch. You will not see the electron unless it has scattered the light, but if it does scatter it then it comes under the Compton effect, and is flipped away. So you do not see where the electron is, but only where it was. To weaken this trouble you might go back to ordinary light, for which the Compton effect is very small, but in doing so you have given up the idea of fixing its position so accurately because you are using a longer wavelength for your microscope, and in a microscope you can never see a position with accuracy better than the wavelength. This is the Uncertainty Principle, that it is not possible to fix both position and velocity of a body simultaneously with unlimited accuracy. There is no limit to the tolerance you may demand for either, but if you make exacting demands on one that automatically makes you relax your demands on the other.

When the theory is worked out in detail the answer can be expressed very easily in terms of tolerances. Measure the position in centimetres, and the velocity in centimetres a second. Then the most accurate tolerances that can be ever obtained obey the rule that the tolerance of the electron's position $\triangle x$ multiplied by the tolerance of its velocity $\triangle v$ obey the rule

$$\triangle x \triangle v = 7 \text{ cm.}^2/\text{sec.}$$

I ought to mention that a similar rule holds for other bodies, but the number on the right is inversely proportional to the mass, so that since the electron is the lightest body existing, it is the one for which the effect is most marked. Since the mass of an electron is about 10^{-27} grm. you can see that the effect for ordinary bodies is not one of a magnitude to cause serious trouble.

The Uncertainty Principle

The Uncertainty Principle is quite fundamental in modern physics. Its effects are inescapable, so that we can see how the idea of tolerance has got to be accepted as one of the basic ideas, and can no longer be fobbed off by saying that with deeper knowledge we could get rid of it. It is the Uncertainty Principle that has finally made tolerance respectable, as I told you earlier it has now become.

There are other ways in which it can be expressed, which from the theoretical point of view are much more powerful, but I shall not go into them. I shall only take one further rather different example of it, because it will connect up with one of my earlier examples, that of weighing the bullets. In Heisenberg's example fixing the position spoiled the velocity, which we express by saying that position and velocity are complementary. In the same way mechanical principles show that energy and time are complementary. Now the principle of relativity shows that energy and mass are the same thing, and therefore the Uncertainty Principle asserts that it takes a certain time to determine a mass with a given precision, and that the smaller tolerance we demand in the mass, the longer we must take in doing the weighing. I shall not attempt to design and explain an experiment to show how this comes about, nor will I go through the calculations, but I will only give you the result. Suppose our bullet weighed 10 grammes, and that as before we want it to a tolerance of one in a thousand, that is to the nearest 1/100 gramme. Then you cannot hope to do this in a time of less than 7×10^{-45} secs. There is evidently a possibility for improvement in our present methods which gave a time of 1 sec.

Are there any further limitations to tolerances in nature besides the Uncertainty Principle? We do not really know at all, but there have been rather plausible conjectures that there are, that for instance there is no meaning in talking of a distance shorter than 10^{-13} cm., which is about the size of the nucleus of the atom. I will not attempt to discuss these rather vague ideas, but at the risk of an anti-climax I shall turn over to quite a different field, where the idea of even finer tolerances is important.

Epsilonology

This is the field of pure mathematics. You will all have heard of the celebrated problem of Achilles and the tortoise. The answer that Achilles would really catch up the tortoise was just as obvious to the Greeks, who propounded the problem as it is to us, but that is not the point. The point is that when you start trying to get down to pure logic there are contradictions involved in the idea of a line made up of points, and the argument can be presented in such a way that it is very hard to see what is wrong with it. That it was hard may be seen by the fact that it took over two thousands years to find the solution. This solution was the act of a number of mathematicians about a hundred years ago. Their work being of a logical kind had to be worked with extreme care, and if you read the proofs they give of some of their important theorems, you are reminded of the way in which a conveyancing lawyer draws up a rather complicated deed, putting into it a lot of things you never thought of. In the course of these proofs great use is made of a particular letter, the Greek letter ϵ; I don't know why it is always this letter that is used, as there is no particular reason why it should be, but the subject is sometimes irreverently called epsilonology on the strength of it. Now the whole thing would have been really fairly simple if mathematicians had been accustomed a hundred years ago to the idea of tolerance, because ϵ is nothing but the tolerance.

I am going to give you an example. What do we mean by $\sqrt{2}$? There is no number which, multiplied by itself gives 2. This troubled the Greek mathematicians a great deal, and indeed they called such numbers irrational or unreasonable numbers and "surds," which could perhaps be best translated by the word "phony." In modern times it became clear that though there was no such number as $\sqrt{2}$, one could pretend there was, and play with it in arithmetic as if it were a genuine number, but still no one could answer the difficulties of the Greeks. The correct answer was given a hundred years ago in this manner. You say there is no such number. I say to you that if you will assign any tolerance you like I can give you a number which will have a square nearer to 2 than your tolerance. I don't care how close a tolerance you fix, I can beat it. The way is obvious. If you say you want a tolerance of a hundredth I give you the square root to two places of decimals, if you say a millionth I give it to six places, and so on. The arguments about surds are sound, not because surds are numbers in the ordinary sense, but because whatever tolerances are assigned, numbers can be found which are closer to the result. I am not going to say that this description would suit the lawyer-like habits of the pure mathematician, but it is not a bad definition of his subject to say that pure mathematics is the branch of physics which is true for any and every tolerance, however small it may be.

I have not traversed the field of tolerances from large numbers, through objects of ordinary size, then through objects so small that we need a powerful microscope to see them, then to the ultimate physical realities, and now down to anything of completely unlimited size. There is no further to go, and so I will conclude by hoping that I have convinced you that the subject is an interesting and important one.

VOTE OF THANKS

Mr. T. H. Turner, proposing a hearty vote of thanks to Sir Charles Darwin, said that the meeting had certainly not lacked warmth in their reception of his lecture. The members really did appreciate the fact that he had come amongst them, for they had rather missed the contact with the National Physical Laboratory which the metallurgical institutions had enjoyed in the days when the late Dr. Rosenhain was the Head of the Metallurgical Division. Being a member of four metallurgical and four engineering institutions, Mr. Turner said he could appreciate fully

Tolerances and Inaccuracies in Physics

the way in which the metallurgists must act as interpreters between pure science and engineering. The old days in which chemistry had ruled all had gone, and it was clear that physics could not rule all; the engineers and metallurgists must try to pick out from all types of pure science the real useful indications in the control of their work. Dr. Rosenhain had acted as an interpreter of new ideas, and his work was of great value. Since the war and since Dr. Desch had left the N.P.L., there had not been the same close connection between the Institutions and the N.P.L. Indeed, some of them hardly knew into what the metallurgical interest of the N.P.L. would develop, because there had grown up the British Cast Iron Research Association and the British Non-Ferrous Metals Research Association, and the Steel Research Association was coming along. But, whatever the development of that Division of the N.P.L., they could not do without it and must contact it at all times. Only on the previous day he had attended a meeting of the Engineering Divisional Council of the British Standards Institution, and it was fair to say that on every sub-committee considered there was a representative from the N.P.L.

It was a tremendous responsibility for any man to direct such an institution, and the Institute appreciated very highly the fact that Sir Charles had found the time to address the members and to show such interest in their work.

Mr. A. E. Peace, seconding, said that perhaps the opportunity to do so had been afforded him because some years ago he had been associated with the preparation of a Paper on tolerances in the dimensions of castings. Having heard Sir Charles Darwin's lecture, he felt that perhaps he had not then quite the right idea on tolerances. The Committee on which he had been working had been a little disappointed by the reception accorded their efforts, but in future the members of the Institute would have no doubt as to the necessity for tolerances, and he had no doubt that they would enhance the usefulness of their products by giving attention to tolerances. The engineer put tolerances on his drawings for machining because he knew he could not achieve extreme accuracy, but only accuracy within a tolerance, but the founder had to make castings to the engineer's requirements, and was not given any tolerance. The founders must fight for that tolerance.

A New Viewpoint

Sir Charles had given the members a new viewpoint, and could be assured that it would be reflected in future in the production of something better than was being produced at present.

The vote of thanks was accorded with enthusiasm.

Sir Charles Darwin, in his response, said the Metallurgical Division of the N.P.L. had been working very hard during the war. It had achieved some quite successful results, largely owing to the energy of Dr. Sykes (who unfortunately had since left). If the engineers and metallurgists had felt neglected by the staff there, it was because the national effort had kept them extremely busy, and because it was extremely difficult to travel about the country. He intended to do all he could, as soon as the war was over, to reform and to see that the staff did get about again as they did before the war.

IRONFOUNDRY FUEL NEWS—IX

The second most frequent "cupola" recommendation made by members of the Regional Panels of the Ironfounding Industry Fuel Committee to foundries which they visit is that the diameter of the cupola should be reduced to be more in keeping with the melting rate which is required. This involves a consideration of "specific melting rate," which is the output in tons per hr. obtained per sq. ft. of cross-sectional area at tuyere level. Experience has shown that a specific melting rate between 0.7 and 0.8 tons per hr. per sq. ft. generally gives the most efficient working. Taking 0.75 tons per hr. per sq. ft. as a mean figure, the accompanying table shows suitable cupola diameters for given melting rates:

Melting rate required (tons/hr.)	1½	2	2½	3	3½	4	4½	5	5½	6	7	8	9	10
Cupola dia. (in.) ..	19	22	25	27	29	31	33	35	37	39	42	44	47	50

It is very frequently found that a cupola diameter is appreciably greater than indicated in the table, and in such cases consideration should be given to the possibility of lining the furnace down to a more appropriate diameter. Such a reduction in diameter results, of course, in a decreased weight of coke bed for a given height, but a more important factor is that an improved charge coke ratio can generally be used. Possible exceptions might be made in the cases of furnaces melting high steel charges (more than, say, 50 per cent. steel), where a specific melting rate below 0.7 tons per hr. per sq. ft. is generally advisable. In cases where a melting rate of less than about 2 tons per hr. is required, it may not always be possible to line down the furnace to its optimum diameter, as difficulties in the way of repairing the small diameter lining would arise.

Special consideration should also be given when a furnace is only used for a very short melt, and when a reduction in lining diameter would mean an abnormally thick lining. In such a case the increased amount of heat absorbed by the lining may more than offset the increased efficiency of the furnace in other directions.

WARTIME CALLS ON WOMEN TO MAKE ALUMINIUM AIR-COOLED CYLINDER HEADS

By M. J. GREGORY, Peoria, Ill., U.S.A.

(American Foundrymen's Association Exchange Paper.)

Women have proved more proficient in this type of work than men

(*Continued from page* 151.)

Making Body Cores

In the making of fin body cores, a great deal of investigation and research was necessary to crystallise thoughts and design machinery for this work. The machinery developed consists of a vibration table for vibrating the facing sand into the fin section, a well-engineered jolt machine, and a push-button, hydraulically-controlled, pattern-locking and rollover-draw combination. This machine is shown within Figs. 5 and 6.

It was found advisable to bake these cores in a special-type oven. The cope and drag cores, which are made within the area marked No. 4 in Fig. 3, are dried in a long continuous horizontal oven, whereas the centre and smaller cores are baked in a vertical oven. The reason for this is that the time cycle for baking and cooling is such that this arrangement is an ideal one. In making body cores, a progressive core line is used, the operations being arranged in such a manner that every woman is performing her operation on one of the six patterns used. Operations are timed so that the cores move down the line until they are completed and loaded on the core rack for baking (see Fig. 7).

Cleaning the Pattern.—The first, and one of the most important, operations on this line is that of cleaning the pattern (see centre operation in Fig. 8). This is done after each pattern is used and is done in a well-ventilated section of the conveyor line, where a solvent is sprayed on the pattern to cut the dirt and

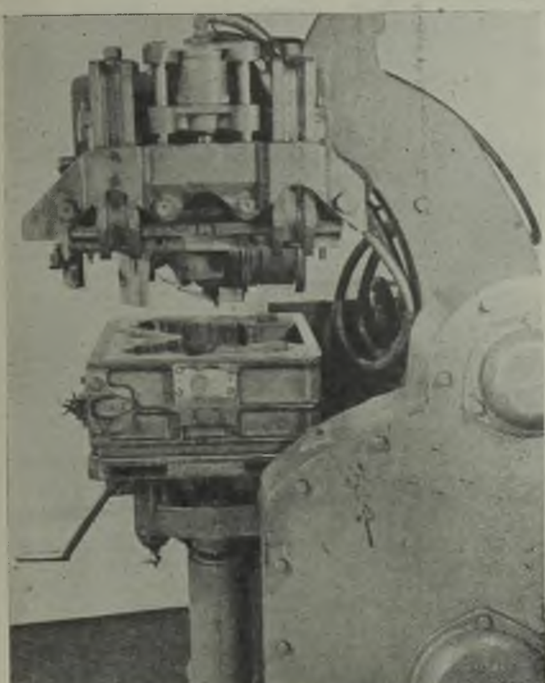

Fig. 5.—Machine for Making Fin Body Cores.

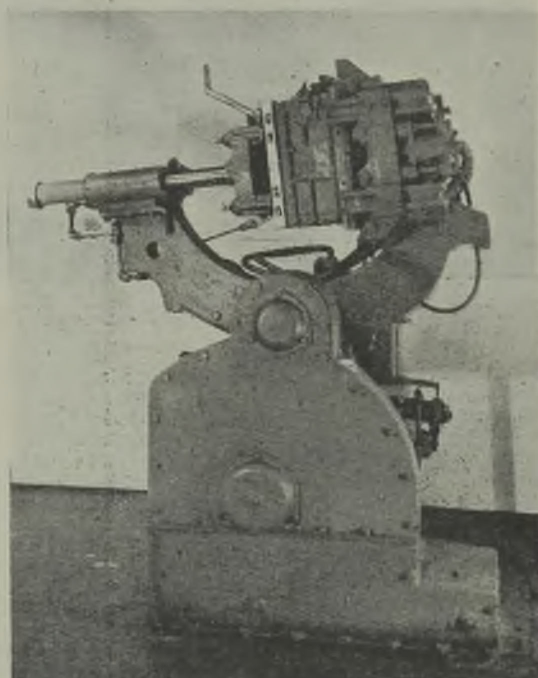

Fig. 6.—The Machine Shown in Fig. 5 but in the Roll-over Position.

Aluminium Air-Cooled Cylinder Heads

oil film. The solvent then is blown out of the pattern with compressed air until all sections are clean and dry. The pattern then is rolled into position by means of a roller conveyor, which is hinged on one end and which may be elevated on the opposite end by an air piston.

Placing Reinforcing Wires.—The next operation requires the dexterous handling of small 18-gauge pin wires which are placed into each fin and laid horizontal to the pattern plate (see operation to right and to left in Fig. 8). Here 61 wires are laid in the cope and 69 in the drag patterns. These wires serve to hold the fragile sand fins to the body of the core before baking. In many experimental tests these moulds have been made and poured without any wires whatsoever. However, it is not deemed a practical operation. Following placing of the wires, an aluminium form is placed in the box around the pattern, following which the assembly is rolled on to a special vibrating machine and clamped to the table by air clamps.

Filling the Fins.—The next operator puts facing sand, from a hopper directly in front of her, on to the pattern and vibrates the sand into the narrow fins. While the sand is vibrating into the pattern, the operator bares the necessary area for nailing, releases the vibrator after allowing sand to pack thoroughly and unclamps the pattern from the machine. The pattern then is rolled along on the conveyor and stopped at a station where additional nails are placed in other strategic positions (see operation in centre of Fig. 9).

The Ramming Operations.—Next the pattern is stopped over a jolt machine and is clamped in place. The remainder of the ram-up frame is filled with backing sand and the cope is jolted 30 times and the drag 40 times. This operation is to protect the facing sand when subjected to the force of air as the remainder of sand is blown into the pattern (see operation to right in Fig. 9). The pattern is then unclamped and rolled from the jolt machine. The operator removes the ram-up frame, places four reinforcement rods on rod stools, and pushes the frame under the core blower. The remainder of the sand then is blown in and the pattern proceeds to the next operator (see operator at machine at left in Fig. 10).

Drawing the Core.—Here the core-dryer plate is placed upon the core, and it is then rolled into the rollover machine. The assembly is clamped into position on the machine and an air hose snapped on to the vibrators, which are mounted on the front of the pattern plate. By pushing a button, the head of the machine, which has four equaliser seats, comes into contact with the core-dryer plate under hydraulic pressure and locks to make the dryer secure. The machine then rolls over, the operator starts the vibrators, and the core loosens slowly for approximately $\frac{3}{4}$ in., from which point it then drops rapidly, easing up just before hitting the roll-out roller conveyor. The entire drawing operation does not require much more than 15 secs.

From the time the pattern enters the position on the rollover machine to the time the machine returns to its original position, elapsed time is approximately 55 secs. After the core is drawn, it is rolled on to a specially made roller conveyor. Meanwhile, the machine is rolled back, the pattern is unclamped and pushed to the return conveyor, where it is picked up by a live roller conveyor and returned to the first operation station to start anew down the progressive core line (see centre of Fig. 10).

Baking the Core.—After the core has been drawn

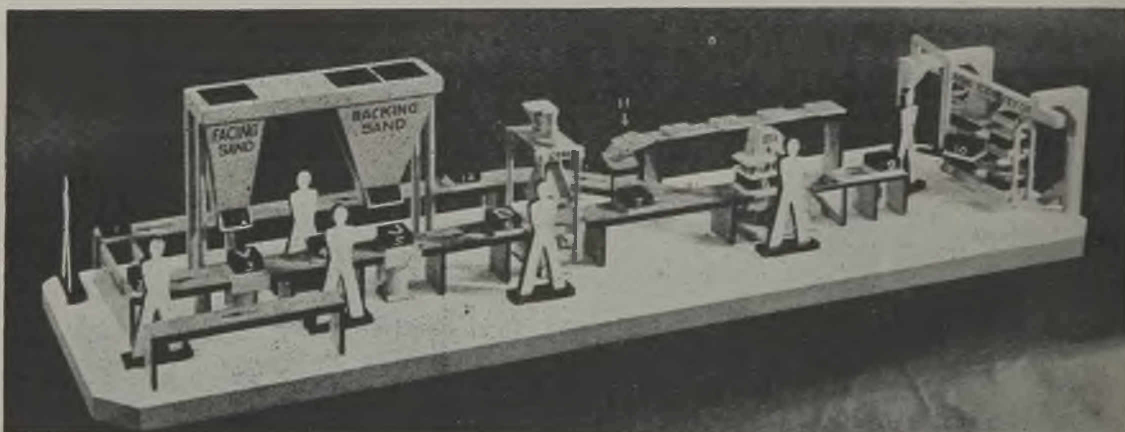

FIG. 7.—MODEL OF THE LINE FOR MAKING BODY CORES

and rolled on to the conveyor at the end of the core line, it is oiled in various locations to give additional strength. The core then is placed on the oven conveyor by a hoist. The operator exerts a force equivalent to only 10 lbs. weight in placing the 120-lb. core on the core rack (see No. 10, Fig. 7). The core rack upon which these cores are loaded is attached to an endless chain and carried into a horizontal oven, which is approximately 800 ft. long. The rack has a time cycle of 9 hrs. in the oven, of which $6\frac{1}{2}$ hrs. is baking time at a temperature of 450 deg. F. (230 deg. C.), which is maintained by two heating units fired with fuel oil or gas, and $2\frac{1}{2}$ hrs. cooling time, which enables the operator to handle cores immediately upon leaving this oven.

The body cores are unloaded by an electric hoist designed especially for this job and handled very capably by one woman. They are unloaded from the core rack to a roller conveyor. There are two of these roller conveyors, one for the cope and the other for the drag. The cores proceed down these conveyors, where they are blown out and inspected before going into the final stages of assembly. All machines on this progressive core line are specially designed and built for the type of work they are doing.

Summary of Method.—The method of making fin body cores outlined above is claimed to be original with Caterpillar Tractor Company. The prior art concerns the placing of a shroud around the fin section of the cylinder head and vibrating sand into the fins, the placing of nails in certain sections, and the jolting of backing sand within the shroud, thus completing the mould at this point to the height of the core box. The shroud is then removed and four rods are placed for reinforcing the core after baking—two rods on stools and two rods at right angles resting on the rods first placed. The box then is placed under a core blower for the completion of the entire core by the core blowing method. The pattern continues on to a rollover machine, which is operated by push-button control. The core is drawn away from the pattern and rolled out on a roller conveyor and, by push-button control, the rollover machine is returned to its original position for removal of the pattern.

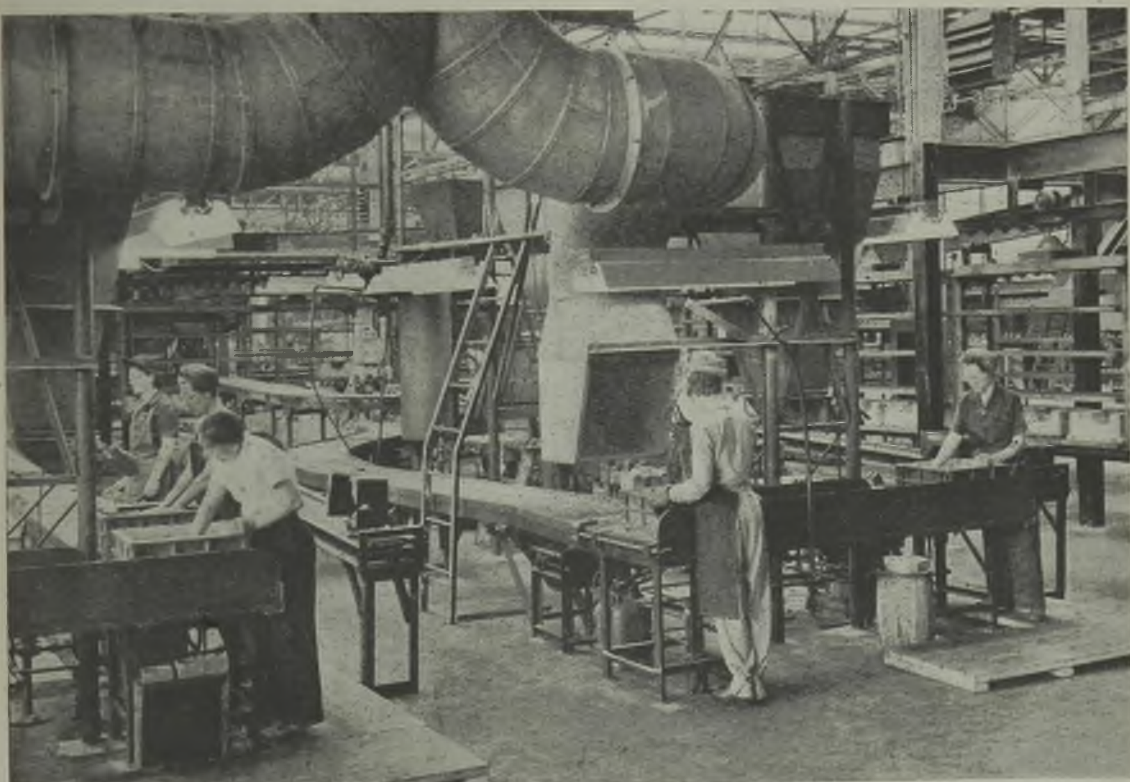

FIG. 8.—IN THIS SECTION THE PATTERNS ARE CLEANED (CENTRE), AND THE CORE WIRES ARE INSERTED.

Aluminium Air-Cooled Cylinder Heads

The pattern then is prepared to continue for another similar operation.

In addition, in another instance the art of blowing the entire core, which consisted of placing the sand within the fins as well as the backing sand by the core blowing method, was developed.

Making Small Cores

The small cores include centre cores, rocker arm, pin and block cores. These are made on three core blowers manipulated by women with great proficiency. In some instances in making this particular casting, chills are required on the surface of the combustion dome area, and in several places within the intake and exhaust areas.

Work benches are placed adjacent to the blowers, and core racks on roller benches are placed back of the operators. After a rack has reached its capacity, it is rolled from its stand to a transfer car, then to the approach of and into a vertical oven. This oven has a cycle of 3½ hrs., a temperature of 460 deg. F. (235 deg. C.), and is fired with fuel-oil or gas. The racks of cores, after being baked, are taken from the opposite side of the oven, placed on a transfer car, and rolled on to a roller conveyor for unloading.

Core Assembling

Small cores, after returning from the bake oven, are unloaded on to a roller conveyor, and proceed to two work benches, where the centre cores are rubbed and pasted together. The centre cores then are gauged to ensure correct alignment and passed on to the next operation, where the joint is mudded.

Core Wash Applied.—The assembled cores are placed on a core plate on the roller conveyor, which circles to the vertical drying oven. There they are painted with a core wash having a specific gravity of 32 deg. Bé. After the core wash has been applied, the cores are dried in an oven before they are set

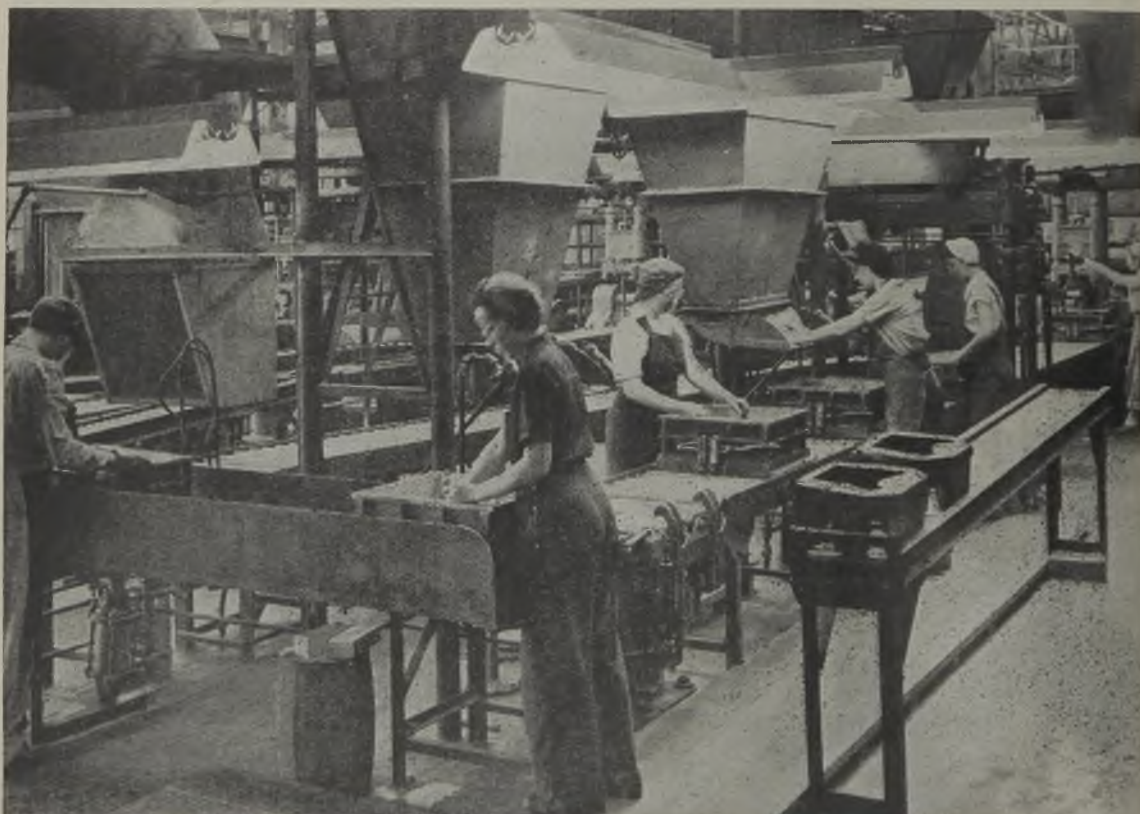

FIG. 9.—SHOWS THE START OF THE CORE MAKING LINE.

into the body cores. Rocker arm and other small cores are inspected and dipped in a proprietary core wash containing ammonium acid fluoride and ammonium borofluoride. These cores are dried in an oven prior to being used.

Dry-Pasted Cores.—After all cores have been thoroughly inspected, the centre core is pasted in the drag core along with the block core. Here an overall gauge is used to assure proper setting of centre core, and the assembly moves down the conveyor and into the vertical drying oven, which drys the pasted cores at a temperature of 330 deg. F. (165 deg. C.) in a 2-hr. cycle. This oven also is fired with fuel oil or gas.

When the cores are ready to leave the drying oven, they are set down on roller conveyors that project into the oven. The cores are pulled from the oven and are ready for the final assembling operations before pouring (see Fig. 11). On this conveyor, both cope and drag cores, which are still on separate conveyors, are blown out thoroughly and again inspected for dirt and defects.

Assembling the Cores.—After passing this rigid inspection, the rocker-arm box cores are sprayed with a rubber compound, which is a gas producing element that assists in cleansing the metal. The rocker-arm cores then are placed in location and gauged to make certain that they are in the correct position. Following this, a carbon deposit is applied on the fin areas with acetylene gas. This carbon deposit acts somewhat as a cushion and assists the metal to flow freelv on the relatively hard surface of the core.

The pin cores are inserted in position, and the entire assembly of cores is moved to the end of the conveyor, where paste is applied on the joint of the drag. The cope is picked up with special tongs actuated by an air-cylinder hoist and is placed directly over the drag and the mould closed. The assembly then is ready for the final closing operation (see operation at left in Fig. 11).

The closed mould is next rolled on to a tip-up fixture which, after the halves have been tightly clamped together, lowers and tips the mould into a vertical position. Another operator, using an air hoist, lifts the assembled mould off the fixture and places it on the nearby power-operated mould conveyor (see operation at right in Fig. 12). The mould is then ready for pouring.

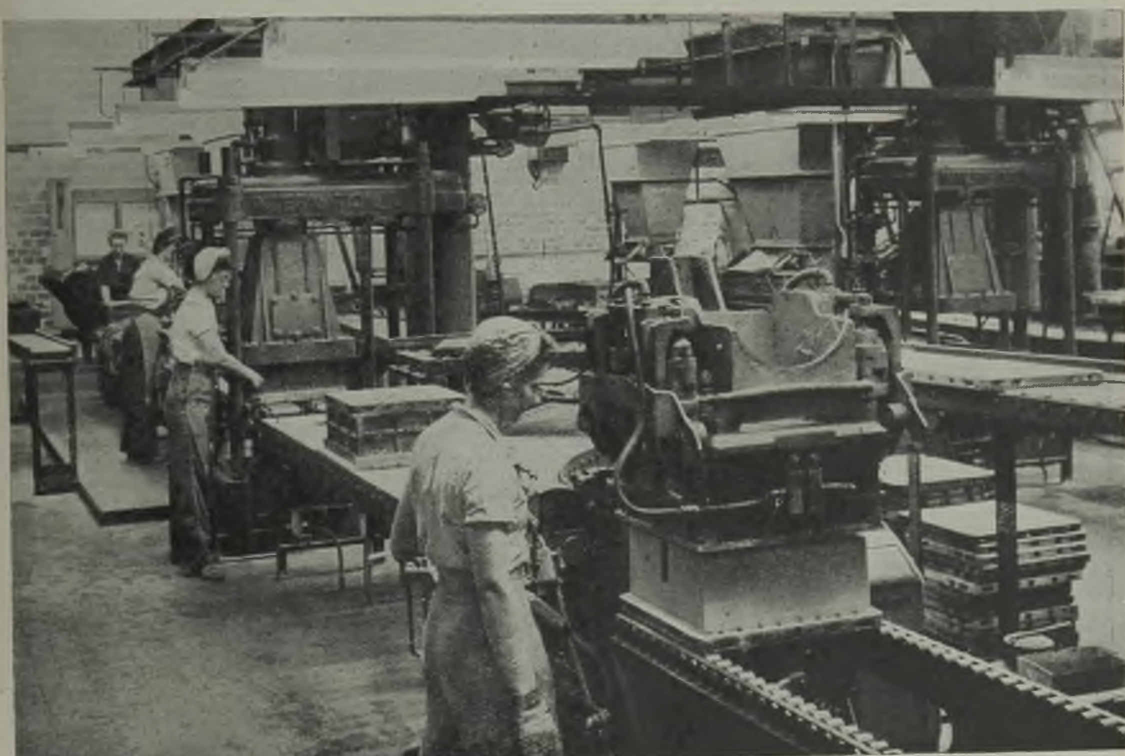

Fig. 10.—The End of the Core Making Line where the Making is Completed by "Blowing."

Aluminium Air-Cooled Cylinder Heads

Properties of Alloy Used

The particular aluminium alloy used in casting air-cooled aluminium cylinder heads is A.M.S. 4220A (Aeronautical Material Specification). It is similar to "Y" Alloy and Alcoa XA142, and has the following specified ranges of composition:

Element.	Per cent.
Copper	3.7 to 4.5
Nickel	1.8 to 2.3
Magnesium	1.2 to 1.7
Chromium	0.15 to 0.25
Titanium	0.07 to 0.18
Silicon	0.60 max.
Iron	0.80 max.

"As cast," the alloy is subject to dimensional changes on heating. To reduce this tendency and to improve the strength of the metal, all castings are subjected to a solution-precipitation heat-treatment. This is discussed in detail later, coming under "Heat-Treating Practice." The minimum physical properties under this specification on heat-treated tensile test-bars cast in green sand moulds are:

Tensile strength, tons per sq. in.	12.9
Elongation in 2 in., per cent.	1.00

Brinell hardness on castings as heat-treated is specified as 75 to 90 (1,000 kg. load, 10 mm. dia. ball).

Gating Practice

For some time before actual production was begun, experiments were made as to pouring methods. In these experiments, castings were gated in the following ways:—(*a*) Pouring one-up down through the riser*; (*b*) pouring two-up down through the riser,* and (*c*)

* These methods are used on smaller sized air-cooled cylinder heads.

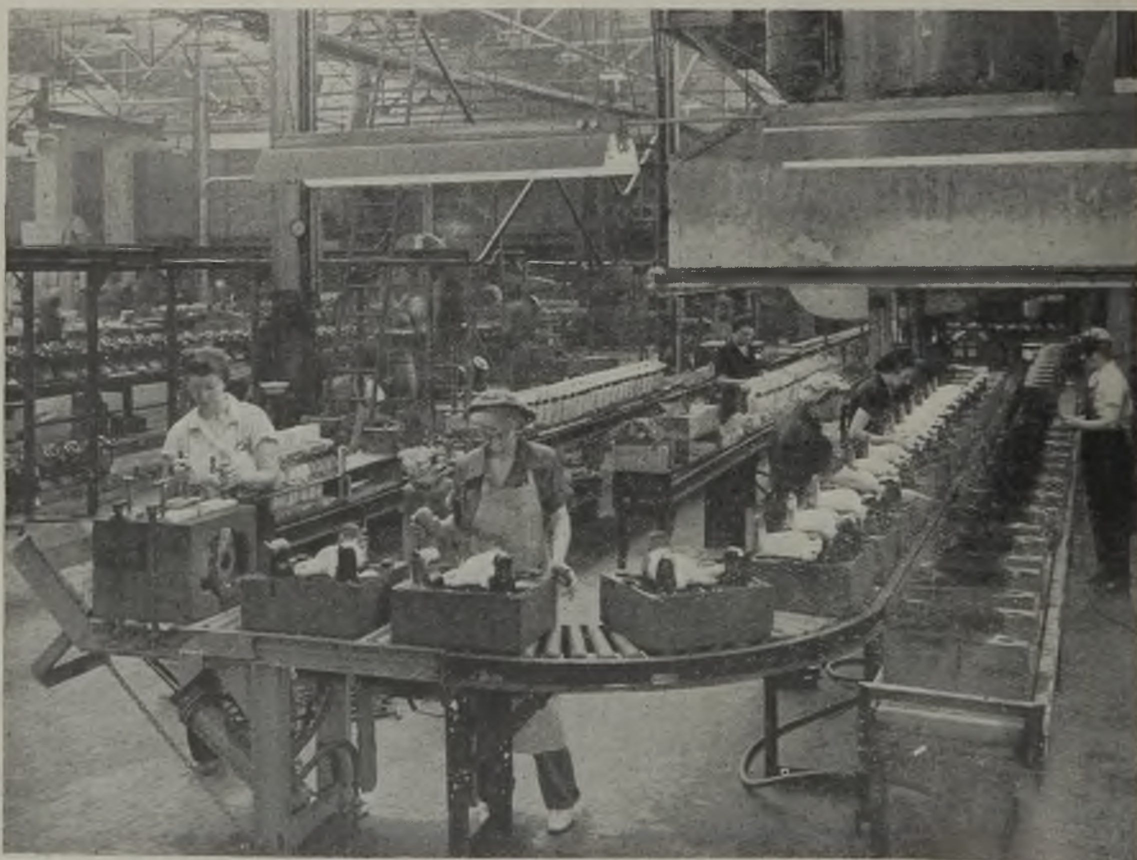

FIG. 11.—MOULD CLOSING SECTION.

pouring down through the rocker arm boxes through sprues outside the core. This method necessitated additional cores and metal. Then began a series of tests and investigations of various locations and manners of gating out of which evolved the present practice. This mode of gating consists of pouring down through the riser at the joint on either side of the casting (see operation in centre in Fig. 12). This method has at least three advantages: (1) It reduces the weight of the remelt metal to 45 per cent. of the actual weight of the rough casting; (2) little difficulty is experienced in completely running the fins, and (3) several cleaning operations are eliminated. The original layout of the melting department was made on the basis of a given hourly production, but with the present method of gating, production was re-scheduled at a considerable increase, using the same facilities.

The melting department consists of nine 1,000-lb. capacity, hydraulic-tilting, pot-type furnaces. These furnaces are arranged in pairs in such a manner that one hydraulic pump and one air blower accommodate two furnaces (see left in Fig. 12). At present oil firing is used; previously, natural gas had been used. Natural gas is preferred for ease of starting and control—especially desirable with women furnace helpers.

Melting Pot Care.—Metal is melted in cast-iron pots bolted in place in the furnaces. These melting pots are thoroughly cleaned before the next heat is charged. Periodically the inside of the melting pot is coated with a proprietary wash to lessen iron pick-up. Thermocouple protection tubes and all tools are cleaned and coated with this wash after each use.

Temperatures Recorded.—Each individual furnace is equipped with a disc-type, continuous, temperature recorder. The recorder face has bold-faced graduations that permit accurate reading from the front of the furnace and up to 20 to 25 ft. away. Chromel-alumel thermocouples, enclosed in cast-iron protection tubes, are used in the melting pot.

(*To be continued.*)

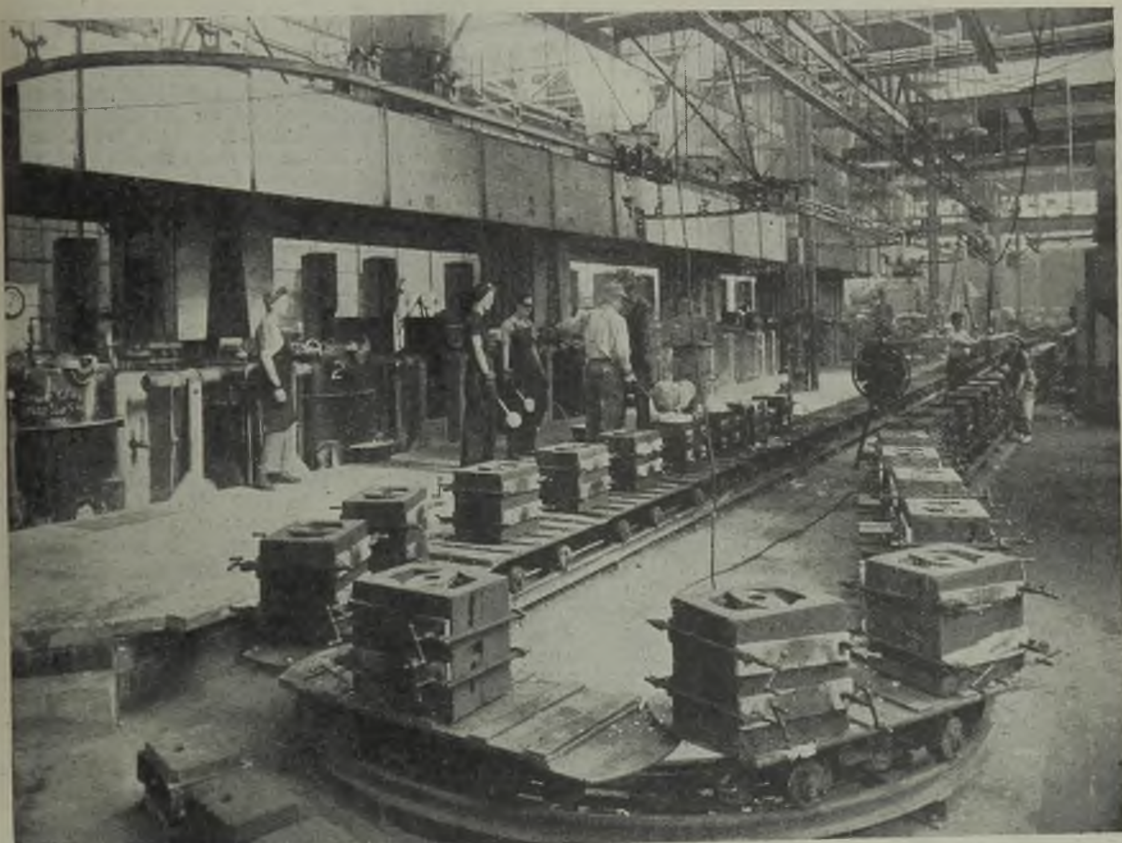

FIG. 12.—THE MELTING PLANT AND POURING STATION.

COMPANY RESULTS

(Figures for previous year in brackets)

Geo. Adlam & Sons—Net profit, £9,707 (£8,466); forward, after payment of preference dividend to May 31, 1934, £3,707 (£4,466).,

Jury Holloware (Stevens)—Net profit to March 31 last, after depreciation and tax, £11,125 (£24,516); dividend of 10% (same); forward, £16,988 (£17,363).

Incledon & Lamberts—Net profit to March 31, £13,206; preference dividend of 10%, less tax, £1,496; ordinary dividend of 12½%, less tax, £10,034; to reserve, £1,500; forward, £662 (£487).

J. Stone & Company—Profit for 1943, after reserve for taxation, £659,989 (£596,762); net profit, £238,305 (£232,126); to reserve, £50,000 (nil); ordinary dividend of 25% (same); forward, £318,646 (£319,441).

Wilkes Berger Engineering—Net profit for 1943, £55,325 (£61,141); to reserve for taxation, £49,459 (£53,341); dividend of 15% and a bonus of 2½% on the ordinary shares (same); forward, £18,773.

Armstrong Stevens & Son—Profit to March 31 last, after E.P.T., £25,555 (£25,267); income-tax, £14,000 (same); deferred repairs, £2,000 (same); dividend of 17½%, less tax, £8,759 (same); forward, £14,310 (£13,514).

Ambrose Shardlow—Profit for the year ended March 31, after providing for taxation, £27,750 (£22,531); exceptional depreciation, £20,000; dividend of 7½% (same) on the ordinary shares; forward, £11,834 (£17,209).

Barrow Hematite Steel—Net profit for 1943, after payment of interest charges and writing off depreciation of fixed assets, £81,010 (£115,067); to general reserve, £50,000 (£100,000); dividend on the ordinary shares of 7½% (5%); forward, £30,298 (£25,809).

Ruston & Hornsby—Net profit to March 31 last, less reserve for E.P.T., £310,913 (£309,705); tax, £141,420 (£139,656); pension reserve, £15,000 (£10,000); reserve for post-war contingencies, £25,000 (same); to general reserve, £22,813 (£30,000); 12½% dividend on the ordinary shares (same); forward, £60,615 (£60,988).

Gjers Mills—Trading profit for 1943, £59,578 (£48,313); bank and other interest, fees and war damage contribution, £4,498 (£3,288); depreciation, £6,000 (£5,000); income-tax and N.D.C., £27,000 (same); net profit, £22,080 (£13,025); dividend of 12½%, less tax, £16,875; to general reserve, nil (£10,000); to deferred repairs and contingencies, £5,000 (nil); forward, £41,121 (£40,916).

CONTRACT OPEN

The date given is the latest on which tenders will be accepted. The address is that from which forms of tender may be obtained.

Manchester, July 6—Cast-iron manhole covers, valve casings, firecock boxes, etc., required by the Waterworks Committee during 12 months ending July 31, 1945. The Secretary, Waterworks Offices, Town Hall, Manchester, 2.

PERSONAL

MR. GEORGE WILLIAM MABE, foundry foreman at Harper Automatic Machine Manufacturing Company, Limited, of Croydon, has been awarded the British Empire Medal.

MR. C. A. STEPHENS has been appointed a director of A. Reyrolle & Company, Limited. Mr. Stephens, who is acting works manager, has been with the company for over 22 years.

MR. JOHN ERIC COX, MR. HARRY JOHN CORNEY, and MR. WILLIAM AUBREY WILLIAMS have been appointed directors of John Williams & Sons (Cardiff), Limited, iron and steel stockholders, founders and engineers.

MR. JOHN VICTOR THOMPSON, joint managing director of J. L. Thompson & Sons, Limited, shipbuilders, Sunderland, and a director of Sir James Laing & Sons, Limited, shipbuilders, Sunderland, has been elected a member of Sunderland Town Council.

MR. HORACE GILBERT WANKLYN DEBENHAM and MR. VAUGHAN PENDRED have been elected directors of the Skinningrove Iron Company, Limited. Mr. Debenham has been general manager of the company and Mr. Pendred sales manager for the past two years.

MR. A. G. TELFER has been appointed chairman and joint managing director of the Scottish Non-Ferrous Tube Industries, Limited. Mr. Telfer has been general manager of the company since its incorporation in 1937, and a director for the last three and a half years.

MR. H. MYERS, who has a record of 53 years' service with Clarke, Chapman & Company, Limited, engineers, ironfounders, etc., of Gateshead, has been presented with cheques from the directors of the firm and the workmen of the foundry department. Mr. Myers is 72 years old, and is still in active work with the firm as a moulder.

MR. J. V. HARTNETT, foundry superintendent at the Ford Works, Dagenham, has been awarded the British Empire Medal for meritorious work in foundry production. He served his engineering apprenticeship in the Naval Dockyard at Queenstown, Ireland. In 1922 he entered the service of Henry Ford, Limited, Cork, as a maintenance engineer. In 1932 Mr. Hartnett came to the Ford factory at Dagenham and later was appointed foundry superintendent.

MR. G. D. HUTCHINS has retired from the secretaryship of the Woodall-Duckham Vertical Retort & Oven Construction Company (1920), Limited, and of Woodall-Duckham (1920), Limited. MR. N. G. LANG, who has held the office of assistant secretary for the past 20 years, has been appointed secretary of these companies as from July 1. Mr. Hutchins has been appointed a director of Woodall-Duckham (1920), Limited, and will continue in the service of the Woodall-Duckham Vertical Retort Company in a consultative capacity.

THE AMALGAMATED ENGINEERING UNION has opened a campaign to reach 100 per cent. union membership on Tyneside.

Raw Material Markets

IRON AND STEEL

The exercise of the utmost economy in the use of fuel and of transport has become an absolute necessity, and since substantial reserves of pig-iron have been accumulated, the stoppage of a few more blast furnaces would create no surprise. Requirements of the foundry trades are definitely on a reduced scale. The decline is more marked at the light-castings foundries than at those engaged in engineering work, but even these latter are less active than they were a couple of months ago, and this is reflected in the more limited demand for pig-iron. The turnover in low-phosphorus and refined iron is still fairly good, but the demand for high-phosphorus iron continues to shrink.

Subject to the provision of the necessary material the steel re-rolling mills are assured of maximum employment throughout the third period. Already commitments extend into the fourth quarter, and to maintain the required outputs of light structural sizes will involve the consumption of big tonnages of both prime billets and defectives. Fortunately, no lack of re-rolling material has yet developed, and it is understood that the Control still has ample resources at its command.

Interest in heavy joists, channels, etc., is at a low ebb, and even the plate mills are not working under the conditions of extreme pressure which prevailed earlier in the year. Still, the weight of orders for plates is ample to keep the mills going at full pressure, and substantial orders have been placed during the past week. The feature of the sheet trade is the widely extended demand for the lighter gauges. Order books still present a healthy appearance, and, if new bookings are coming along less freely, there is still sufficient work in hand to keep the mills busy throughout the summer months. Mining requirements in steel are on a heavy scale, and requisitions from builders of rolling stock reflect the high activity of this branch of industry.

NON-FERROUS METALS

There have been few developments in the non-ferrous metal industry recently. Conditions generally are not so busy as they were, and there have been considerable setbacks in activity in the case of brass billets, where there has been a sharp reduction in the demand, leaving many foundries short of work. Nevertheless, a large amount of metal is still being absorbed, and on the whole, output continues at a high level.

The copper position in this country seems to be satisfactory. There has been no tightening up of supplies, and the situation is causing no anxiety at the moment, while there are no signs of any trouble in the future. It is still, however, the policy of the Control not to release any copper for non-essential purposes. Supplies now held are fully adequate to meet the requirements of priority consumers, and it is understood that substantial reserve stocks are held to cope with any possible eventuality.

Both in this country and in America, the tin supply position continues to be reasonably comfortable. There have been no changes of any great significance, and supplies are adequate for priority needs, but are insufficient to permit metal being released for other purposes.

Lead is in sufficient supply for war requirements, but there is no surplus available to ordinary users. If the strike among the Mexican miners is prolonged it may have serious results, but an early settlement seems likely; the strike has been in progress since June 8.

NEWS IN BRIEF

PRE-APPRENTICESHIP training courses are to be established in Scotland for boys who have had a three years' secondary course and who intend to enter the engineering industry. The course is full-time and extends over a year, and includes workshop practice and theoretical subjects.

THE REPORT of the directors of the Barrow Hematite Steel Company, Limited, for 1943 states that during the year the bank loan has been repaid and since the end of the year the debenture stock has been liquidated. The demand for pig-iron has, it is stated, remained constant, and the mines have provided regular supplies of good ore. The limestone and lime undertakings are being further developed and should, it is added, be of increasing value to the company.

ALL COPIES of the 1941-42 Proceedings of the Institute of British Foundrymen mailed to members of the South African Branch were lost by enemy action, and the Institute's stocks are insufficient to enable replacement copies to be sent to the Dominion members. The Council of the Institute will therefore be grateful to any members who can donate copies of that volume for transmission to South Africa. Copies should be sent to the Institute's office, St. John Street Chambers, Deansgate, Manchester, 3.

A JOINT MEETING of the Iron and Steel Institute and the Sheffield Branch of the Institute of British Foundrymen will be held on Wednesday, July 19, at the Royal Victoria Hotel, Sheffield, beginning at 7 p.m., when a Paper by Mr. P. C. Fassotte, entitled "Developments in the Design and Use of Side Blown Converter Plants," will be discussed. Members of the Sheffield Society of Engineers and Metallurgists and members of the Sheffield Metallurgical Association are invited to attend and to take part in the discussion.

MR. ROBERT HENRY WOODWARD, of Walker & Woodward, brass founders, Birmingham, whose family became connected with the firm eighty years ago, about 75 years after it was established in 1790, has died at the age of 67. Mr. R. H. Woodward had been serving the firm actively for some fifty years.

CURRENT PRICES OF IRON, STEEL AND NON-FERROUS METALS

(Delivered, unless otherwise stated)

Wednesday, June 28, 1944

PIG-IRON

Foundry Iron.—CLEVELAND No. 3: Middlesbrough, 128s.; Birmingham, 130s.; Falkirk, 128s.; Glasgow, 131s.; Manchester, 133s. DERBYSHIRE No. 3: Birmingham, 130s.; Manchester, 133s.; Sheffield, 127s. 6d. NORTHANTS No. 3: Birmingham, 127s. 6d.; Manchester, 131s. 6d. STAFFS No. 3: Birmingham, 130s.; Manchester, 133s. LINCOLNSHIRE No. 3: Sheffield, 127s. 6d.; Birmingham, 130s.

(*No. 1 foundry 3s. above No. 3. No. 4 forge 1s. below No. 3 for foundries, 3s. below for ironworks.*)

Hematite.—Si up to 2.25 per cent., S & P 0.03 to 0.05 per cent: Scotland, N.-E.Coast and West Coast of England, 138s. 6d.; Sheffield, 144s.; Birmingham, 150s.; Wales (Welsh iron), 134s. East Coast No. 3 at Birmingham, 149s.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, 140s. 6d., delivered Birmingham.

Scotch Iron.—No. 3 foundry, 124s. 9d.; No. 1 foundry, 127s. 3d., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, 174s.; South Zone, 176s. 6d.

Refined Malleable.—North Zone, 184s.; South Zone, 186s. 6d.

Cold Blast.—South Staffs, 227s. 6d.

(NOTE.—*Prices of hematite pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton.*)

FERRO-ALLOYS

(Per ton unless otherwise stated, basis 2-ton lots, d/d Sheffield works.)

Ferro-silicon (5-ton lots).—25 per cent., £21 5s.; 45/50 per cent., £27 10s.; 75/80 per cent., £43. Briquettes, £30 per ton.

Ferro-vanadium.—35/50 per cent., 15s. 6d. per lb. of V.

Ferro-molybdenum.—70/75 per cent., carbon-free, 6s. per lb. of Mo.

Ferro-titanium.—20/25 per cent., carbon-free, 1s. 3½d. lb.

Ferro-tungsten.—80/85 per cent., 9s. 8d. lb.

Tungsten Metal Powder.—98/99 per cent., 9s. 9½d. lb.

Ferro-chrome.—4/6 per cent. C, £59; max. 2 per cent. C, 1s. 6d. lb.; max. 1 per cent. C, 1s. 6½d. lb.; max. 0.5 per cent. C, 1s. 6¾d. lb.

Cobalt.—98/99 per cent., 8s. 9d. lb.

Metallic Chromium.—96/98 per cent., 4s. 9d. lb.

Ferro-manganese.—78/98 per cent., £18 10s.

Metallic Manganese.—94/96 per cent., carb.-free, 1s. 9d. lb.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms and Slabs.—BASIC: Soft, u.t., 100-ton lots, £12 5s.; tested, up to 0.25 per cent. C, £12 10s.; hard (0.42 to 0.60 per cent. C), £13 17s. 6d.; silico-manganese, £17 5s.; free-cutting, £14 10s. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £15 15s.; case-hardening, £16 12s. 6d.; silico-manganese, £17 5s.

Billets, Blooms and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £13 17s. 6d.; basic hard, 0.42 to 0.60 per cent. C, £14 10s.; acid, up to 0.25 per cent. C, £16 5s.

Sheet and Tinplate Bars.—£12 2s. 6d., 6-ton lots.

FINISHED STEEL

[*A rebate of 15s. per ton for steel bars, sections, plates, joists and hoops is obtainable in the home trade under certain conditions.*]

Plates and Sections.—Plates, ship (N.-E. Coast), £16 3s.; boiler plates (N.-E. Coast), £17 0s. 6d.; chequer plates (N.-E. Coast), £17 13s.; angles, over 4 un. ins., £15 8s.; tees, over 4 un. ins., £16 8s.; joists, 3 in. × 3 in. and up, £15 8s.

Bars, Sheets, etc.—Rounds and squares, 3 in. to 5½ in., £16 18s.; rounds, under 3 in. to ⅝ in. (untested), £17 12s.; flats, over 5 in. wide, £15 13s.; flats, 5 in. wide and under, £17 12s.; rails, heavy, f.o.t., £14 10s. 6d.; hoops, £18 7s.; black sheets, 24 g. (4-ton lots), £22 15s.; galvanised corrugated sheets (4-ton lots), £26 2s. 6d.; galvanised fencing wire, 8g. plain, £26 17s. 6d.

Tinplates.—I.C. cokes, 20 × 14 per box, 29s. 9d., f.o.t. makers' works, 30s. 9d., f.o.b.; C.W., 20×14, 27s. 9d., f.o.t., 28s. 6d., f.o.b.

NON-FERROUS METALS

Copper.—Electrolytic, £62; high-grade fire-refined, £61 10s.; fire-refined of not less than 99.7 per cent., £61; ditto, 99.2 per cent., £60 10s.; black hot-rolled wire rods, £65 15s.

Tin.—99 to under 99.75 per cent., £300; 99.75 to under 99.9 per cent., £301 10s.; min. 99.9 per cent., £303 10s.

Spelter.—G.O.B. (foreign) (duty paid), £25 15s.; ditto (domestic), £26 10s.; "Prime Western," £26 10s.; refined and electrolytic, £27 5s.; not less than 99.99 per cent., £28 15s.

Lead.—Good soft pig-lead (foreign) (duty paid), £25: ditto (Empire and domestic), £25; English, £26 10s.

Zinc Sheets, etc.—Sheets, 10g. and thicker, ex works, £37 12s. 6d.; rolled zinc (boiler plates), ex works, £35 12s. 6d.; zinc oxide (Red Seal), d/d buyers' premises, £30 10s.

Other Metals.—Aluminium, ingots, £110; antimony, English, 99 per cent., £120; quicksilver, ex warehouse, £68 10s. to £69 15s.; nickel, £190 to £195.

Brass.—Solid-drawn tubes, 14d. per lb.; brazed tubes, 16d.; rods, drawn, 11⅜d.; rods, extruded or rolled, 9d.; sheets to 10 w.g., 11⅛d.; wire, 10⅞d.; rolled metal, 10½d.; yellow metal rods, 9d.

Copper Tubes, etc.—Solid-drawn tubes, 15¼d. per lb.; brazed tubes, 15¼d.; wire, 10d.

Phosphor Bronze.—Strip, 14½d. per lb.; sheets to 10 w.g., 15¼d.; wire, 16½d.; rods, 16½d.; tubes, 21½d.; castings, 20d., delivery 3 cwt. free. 10 per cent. phos. cop. £35 above B.S.; 15 per cent. phos. cop. £43 above B.S.; phosphor tin (5 per cent.) £40 above price of English ingots. (C. CLIFFORD & SON, LIMITED.)

Nickel Silver, etc.—Ingots for raising, 10d. to 1s. 4d. per lb.; rolled to 9 in. wide, 1s. 4d. to 1s. 10d.; to 12 in. wide, 1s. 4¼d. to 1s. 10¼d.; to 15 in. wide, 1s. 4½d. to 1s. 10½d.; to 18 in. wide, 1s. 5d. to 1s. 11d.; to 21 in. wide, 1s. 5½d. to 1s. 11½d.; to 25 in. wide, 1s. 6d. to 2s. Ingots for spoons and forks, 10d. to 1s. 6½d. Ingots rolled to spoon size, 1s. 1d. to 1s. 9½d. Wire round, to 10g., 1s. 7½d. to 2s. 2½d., with extras according to gauge. Special 5ths quality turning rods in straight lengths, 1s. 6½d. upwards

NON-FERROUS SCRAP

Controlled Maximum Prices.—Bright untinned copper wire, in crucible form or in hanks, £57 10s.; No. 1 copper wire, £57; No. 2 copper wire, £55 10s.; copper firebox plates, cut up, £57 10s.; clean untinned copper, cut up, £56 10s.; braziery copper, £53 10s.; Q.F. process and shell-case brass, 70/30 quality, free from primers, £49; clean fired 303 S.A. cartridge cases, £47; 70/30 turnings, clean and baled, £43; brass swarf, clean, free from iron and commercially dry, £34 10s.; new brass rod ends, 60/40 quality, £38 10s.; hot stampings and fuse metal, 60/40 quality, £38 10s.; Admiralty gunmetal, 88-10-2, containing not more than ½ per cent. lead or 3 per cent. zinc, or less than 9½ per cent. tin, £77, all per ton, ex works.

Returned Process Scrap.—(Issued by the N.F.M.C. as the basis of settlement for returned process scrap, week ended June 24, where buyer and seller have not mutually agreed a price; net, per ton, ex-sellers' works, suitably packed):—

Brass.—S.A.A. webbing, £48 10s.; S.A.A. defective cups and cases, £47 10s.; S.A.A. cut-offs and trimmings, £42 10s.; S.A.A. turnings (loose), £37; S.A.A. turnings (baled), £42 10s.; S.A.A. turnings (masticated), £42; Q.F. webbing, £49; defective Q.F. cups and cases, £49; Q.F. cut-offs, £47 10s.; Q.F. turnings, £38; other 70/30 process and manufacturing scrap, £46 10s.; process and manufacturing scrap containing over 62 per cent. and up to 68 per cent. Cu, £43 10s.; ditto, over 58 per cent. to 62 per cent. Cu, £38 10s.; 85/15 gilding metal webbing, £52 10s.; 85/15 gilding defective cups and envelopes before filling, £50 10s.; cap metal webbing, £54 10s.; 90/10 gilding webbing, £53 10s.; 90/10 gilding defective cups and envelopes before filling, £51 10s.

Cupro Nickel.—80/20 cupro-nickel webbing, £75 10s.; 80/20 defective cups and envelopes before filling, £70 10s.

Nickel Silver.—Process and manufacturing scrap; 10 per cent. nickel, £50; 15 per cent. nickel, £56; 18 per cent. nickel, £60; 20 per cent. nickel, £63.

Copper.—Sheet cuttings and webbing, untinned, £54; shell-band plate scrap, £56 10s.; copper turnings, £48.

IRON AND STEEL SCRAP

(*Delivered free to consumers' works. Plus 3¾ per cent. dealers' remuneration.* 50 *tons and upwards over three months, 2s. 6d. extra.*)

South Wales.—Short heavy steel, not ex. 24-in. lengths, 82s. to 84s. 6d.; heavy machinery cast iron, 87s.; ordinary heavy cast iron, 82s.; cast-iron railway chairs, 87s.; medium cast iron, 78s. 3d.; light cast iron, 73s. 6d.

Middlesbrough.—Short heavy steel, 79s. 9d. to 82s. 3d.; heavy machinery cast iron, 91s. 9d.; ordinary heavy cast iron, 89s. 3d.; cast-iron railway chairs, 89s. 3d.; medium cast iron, 79s. 6d.; light cast iron, 74s. 6d.

Birmingham District.—Short heavy steel, 74s. 9d. to 77s. 3d.; heavy machinery cast iron, 92s. 3d.; ordinary heavy cast iron, 87s. 6d.; cast-iron railway chairs, 87s. 6d.; medium cast iron, 80s. 3d.; light cast iron, 75s. 3d.

Scotland.—Short heavy steel, 79s. 6d. to 82s.; heavy machinery cast iron, 94s. 3d.; ordinary heavy cast iron, 89s. 3d.; cast-iron railway chairs, 94s. 3d.; medium cast iron, 77s. 3d.; light cast iron, 72s. 3d.

(Note.—*For deliveries of cast-iron scrap free to consumers' works in Scotland, the above prices less 3s. per ton, but plus actual cost of transport or 6s. per ton, whichever is the less.*)

SMALL ADVERTISEMENTS

NOTICE

Small Advertisements in this section of the Journal are accepted at the *prepaid* rate of 2d. per word in ordinary type and 3d. per word in capitals.
Minimum charge for one insertion 4/-.

SITUATIONS

SALES MANAGER (45); high-duty alloy and grey iron repetition castings; sound connections now and for post-war in engineering and allied industries; free shortly.—Box 558, FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

ASSISTANT FOUNDRY MANAGER required for Light Castings Iron Foundry; knowledge of continuous machine moulding methods essential; excellent post-war prospects.—Box 556, FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

REPRESENTATIVE for Scotland, on commission basis, required by well-known manufacturers of foundry supplies; good connections with foundries essential. —Offers with details to Box 544, FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

AGENCIES

AGENCIES WANTED.—N.E. Coast firm, established 60 years, having wide selling connections Iron and Steel Works, Foundries, etc., seek additional Agencies.—Box 560, FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

MOULDER.—Agent for everything for a Foundry; requires commission only; ground covered, North Lincs and all of Yorks.—Box 564, FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

MACHINERY

WIZARD type Sand Blast for sale; good condition; recently overhauled; offers.—Apply SANDWELL CASTING Co., Bank Street Foundry, West Bromwich.

3-TON capacity, HEROULT type, Electric Tilting Steel Furnace, having electrically-operated electrodes, automatic control panel and transformer, for 6,600 volts, 3-phase, 50 cycles supply.—NEWMAN INDUSTRIES, LTD., Yate, Bristol.

MACHINERY—*contd.*

SKLENAR Patent Melting Furnaces; coke- or oil-fired; capacity 2 tons, 1 ton, ½ ton, 500 lbs.—SKLENAR PATENT MELTING FURNACES, LTD., East Moors Road, Cardiff.

600 CUB. FT. per min., vertical, water-cooled, 4-cylinder, Air Compressor, by BROOM & WADE; 100 lbs. sq. in. working pressure; vee-rope driven by 100 h.p. S.R. motor, for 400-volt, 3-phase, 50 cycles; complete with starter and control gear; complete with receiver; new 1932; inspection near Leeds.—NEWMAN INDUSTRIES, LTD., Yate, Bristol.

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"POLFORD" CORE SAND MIXERS, TILTING and CRUCIBLE FURNACES, MOULD DRYER, RIDDLE, SCREEN, etc. WRITE FOR PRICES AND PARTICULARS.
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Grams: "Forward." 'Phone: 26322 (16 lines.)

FOR SALE.—B.S.2 Midland Monolithic Black Seam, coke-fired, pit-type, 200 lbs. brass capacity, forced draught Furnace, with or without blower and motor for 346 volts, 3-phase, 50 cycles.—WHYTE & EDWARD (METALS), LTD., Victoria Dock, Dundee.

MISCELLANEOUS.
Standard Size Adaptable Moulding Machines, etc.
"Ajax" No. 9 Macdonald Pneumatic Jolter turnover table, 36 in. by 46 in.
Coal and Coke Crusher; 2 ft. 6 in. dia.
Brealey Type Sand Disintegrator.
Macnab 5 ft. 6 in. Sand Mills, Size No. 2, with or without 3/50/400 v. motor.
Broadbent Brick Crusher; 8 in. jaw.
Broadbent Brick Crusher; 11 in. jaw.
Sandblasting Plant; 50 Air Compressors; 500 Electric Motors, Dynamos, etc.
S. C. BILSBY,
CROSSWELLS ROAD, LANGLEY,
NR. BIRMINGHAM.
Broadwell 1359.

MISCELLANEOUS

REFRACTORY MATERIALS.—Moulding Sand, Ganister, Limestone, Core-Gum; competitive prices quoted.—HENSALL SAND Co., LTD., Silver Street, Halifax. Yorks.

PATTERNS for all branches of Engineering, for Hand or Machine Moulding.—FURMSTON AND LAWLOR, Letchworth.

MISCELLANEOUS—*contd.*

NON-FERROUS FOUNDRY, capacity available, including sand blasting; competitive prices quoted.—ALBUTT, SON & JACKSON, Valve Makers and Brass Founders, Greenmount Works, Halifax.

CAPACITY REQUIRED
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Up to One Ton Weekly
From Own Patterns

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14½ in. outside dia. by 7 in. inside dia.
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Made by Weir. Unused.

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ST. GEORGE'S ENGINEERS LTD MANCHESTER

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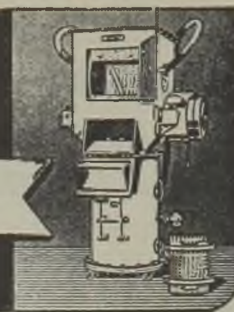

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UP TO HIGHEST DIMENSIONS

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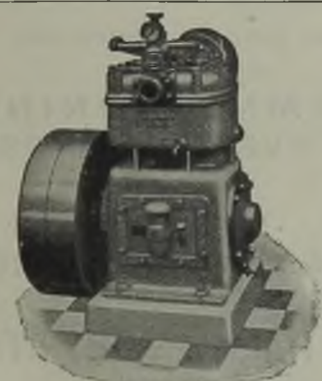

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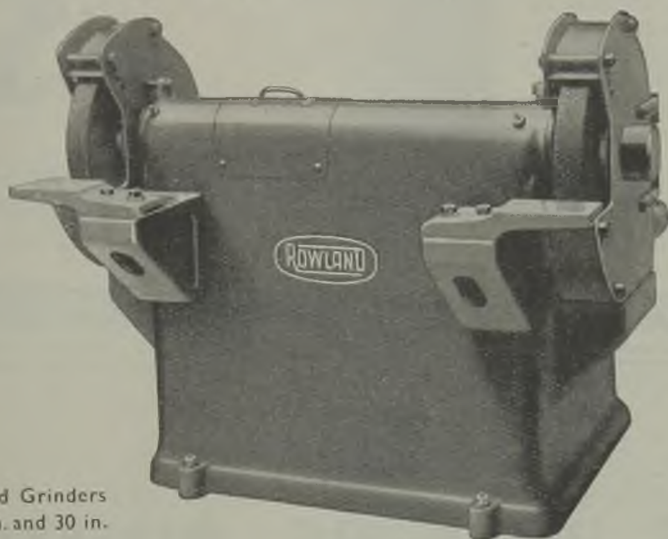

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