

profession of a surgeon. Nevertheless, I have performed hundreds of experiments; and in the very rare cases where great pain was inevitable, the performance has been very distressing; but in all cases I should vehemently protest against the accusation that it was indifference or cruelty which enabled the experiments to be performed.

It is but right that I should acknowledge that Prof. Foster's communication of December 11 has shown me the error of my interpretation of his hypothesis.

GEORGE HENRY LEWES

I WISH briefly to point out the grounds upon which persons who are every bit as tender-hearted and as sympathetic with Nature as any ante-vivisectionist may claim to be, justify what X. condemns. In order that a part of the order of Nature may be ascertained, it is necessary that vivisection be largely practised. Those who practise it do so under a sense of solemn and even sacred responsibility. To suggest the word "cruelty" in connection with their proceedings is an injustice which only profound ignorance and inability to realise the motives of other men can excuse. There is no lack of sympathy with the probable sufferings of animals experimented upon in the mind of the physiologist. He suffers with them, and, as I know of one eminent experimenter, is sometimes disabled by emotion from continuing a research. But the recognition of a higher duty than regard to his own transient impulses or the brief sufferings of a lower animal usually completely controls the experimenter's thought and action, and the mutual suffering of both vivisector and vivisected becomes a sacrifice offered up on the altar of Science. My conviction is that, especially in dealing with such animals as the dog, the experimenter is no less constrained to inflict suffering at which his feelings revolt, by the presence of a noble ulterior motive, than is the surgeon who does not flinch from subjecting his brother-man to the certainty of the direst pain and the imminent risk of death.

No one has a right to *assume* that any other man, still less a whole body of men, is so fiendish as to take any pleasure in the evidences of an animal's sufferings, or so dull as not himself to feel distress when viewing those sufferings. If man is willing to suffer this mental pain for a high end, may he not exact some contribution from the animal world, who after all will benefit as well as he by the progress of Science. It is futile to bewail "the tremendous cost" at which such progress is made. Nature is inconceivably costly, if we choose to put things in that way, for no progress is made without endless suffering and immense destruction. Our very dinner-tables reek with the evidences of "the tremendous cost"—the pangs of slaughtered sheep, the groans of over-worked horses, the dishonourment of Nature's sacred face by agriculture—by which our corporeal means of progress is attained. And are we to be so inconsistent as to refuse to undertake the very highest occupation of humanity, the ascertainment of the order of Nature, because it adds to this "cost" of our existence?

The attempt to raise the question of the "rights" of the animal world in this connection seems to me to involve a very large assumption. I am not prepared to admit that animals have *any* "rights" in the sense that men have them. I could never subject a human being to vivisection for the purposes of scientific progress for much the same reason that, if starving among the Arctic snows, I should feel bound to starve with my companion, rather than kill and feed on him. The recognition of the inviolability of one's fellow-man except under conditions authorised by the community, is the very foundation of human society, and our relations to animals cannot in the remotest degree be assimilated to the relation thus established between man and man. Our conduct towards animals, as towards other living and even inanimate things, must be determined in quite

a different way, and by very different reasons. It is, I am inclined to believe, solely the consideration of how we ourselves are affected—whether injuriously or beneficially—by any particular line of conduct towards beings other than men, that can be allowed to guide us in such matters. Anything of the nature of cruelty is obviously thus condemned, and all wanton disrespect to the persons of both living and inanimate things, no less so.

Whilst thus refusing to admit anything like the "right" claimed by man from man, for lower animals, we are not led to regard them with less affection, nor to treat them with diminished tenderness. The conviction that they are ours with which to do what seems good to us, must even increase our disposition to kindly treatment.

Let cases of cruelty, whether from man to man, to woman or child, to horse, fox, or dog, rabbit or frog, be searched out, exposed, and the perpetrator condemned; but unless such persons as X. are prepared to accuse such men as Michael Foster and George Henry Lewes of specific acts of cruelty, they are not justified in making physiology the text for heart-rending appeals to a public imperfectly acquainted with the facts.

E. R. L.

THE THIRTY-TON STEAM-HAMMER AT THE ROYAL ARSENAL, WOOLWICH

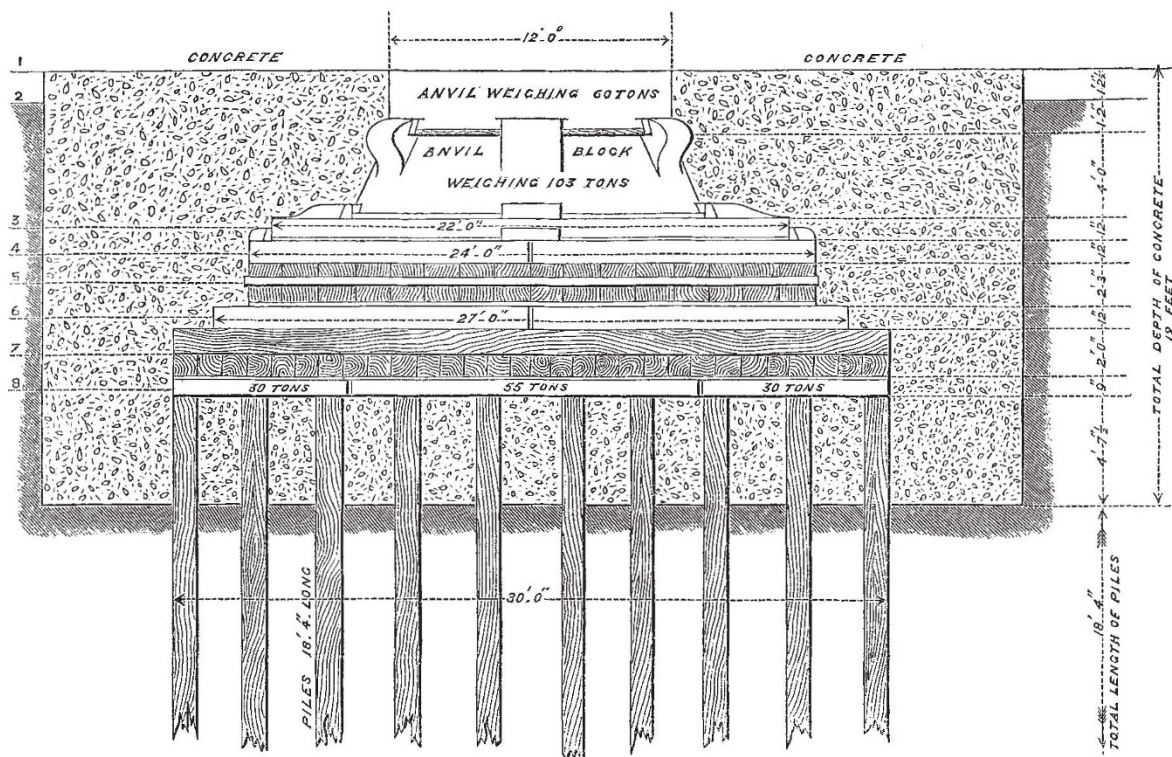
FOR the past two years a stupendous undertaking has been in course of development at the Royal Arsenal, Woolwich, which bids fair to rival in point of solidity and grandeur of dimensions the works of ancient Egypt itself. We allude to the gigantic steam-hammer which is being erected in the gun factories, for the purpose of welding more swiftly and efficaciously than can possibly be done at present the coils of which such massive pieces of ordnance as our modern "Woolwich Infants" consist. The first phase in this undertaking, viz. the laying of an appropriate foundation for the hammer, has now been accomplished, and will be the subject of the present paper. The hammer itself, which is still in an unfinished condition, although rapidly approaching completion, will be treated of subsequently. It is out of the question, in the compass of a brief sketch, to give an adequate idea of all the labour and thought that has been expended upon these foundations, but an endeavour will be made to condense as far as possible the most interesting part of their history into a few words.

The foundations were commenced in a soft, spongy soil, which is the substratum upon which all the Arsenal has been built. A hundred piles of pine-wood shod with iron a foot square each, were driven into the earth so as to form an area of thirty feet square; and when the heads were sawn off to an even surface, their average length was 18 feet 4 inches. Concrete was then filled in all round to the top of the piles, and three cast-iron plates, weighing respectively 30, 55, and 30 tons, were placed upon the heads of the piles. But before proceeding further with the building up of the foundations, we must describe the nature of the castings alluded to. They were all run in the foundry of the Royal Gun Factories, and consisted of about one-fifth of Calder pig-iron to four-fifths of scrap metal containing old broken-up shell, and shot, &c. The metal, after being taken from a number of cupolas in which it was melted, was collected in huge reservoirs, called "sows," and kept in a liquid state during the time necessarily occupied in filling the sows by a quantity of firewood being piled on top, which of course was continually in a state of ignition. This process occupied some eight or ten hours. At a given signal the sows were tapped, and the iron run out into open sand moulds in the floor of the foundry. The removal of these gigantic castings to their destination was a matter involving considerable difficulty. Two sets of worn-out gun-trucks were laid down upon either side of the road, and planks

of African oak, placed longitudinally upon these, thus forming a rude railway. Rollers consisting of the unworked tubes of guns were then obtained from the gun factories, and laid across the planks. A sleigh, composed of two massive bars of wrought-iron turned up in front, and attached together by baulks of timber, was then placed upon the rollers, and surmounted first by the cast-iron plate to be carried, then by a movable or revolving crane. The sleigh being drawn forwards by a crab-winch and tacking, as the rollers were successively passed over the crane lifted up those that were behind, and, swinging round, deposited them in front, presenting a fresh rolling surface upon each occasion. Thus the plates were each slowly moved from the foundry to the foundation pit. But there was another difficulty. As it was necessary to have "joggles," or projections upon the summit of several of the plates for the superincumbent ones to rest within, and

in open castings it was impossible to cast them upon an upper surface, the joggles had to be formed upon the lower surface, and the plates to be reversed in position afterwards. This was done by casting trunnions upon the edges of the plates, nearer one end than the other, and then swinging the plates over the foundation pit by these trunnions, until the heavier half descended, drawing back the heavier portion by a crab-winch, and finally permitting the lighter portion gradually to descend, the trunnion supports being withdrawn, and the edge of the plate resting on the ground forming a fulcrum. The trunnions do not appear in our engraving, but the joggles may be seen upon the three upper sets of castings.

We will now revert to the laying of the foundations. Over the whole extent of the lower plates a thin layer of rock-elm planks was laid, this being the most indestructible kind of wood known, it being necessary to



Foundations for 30-ton Steam Hammer.

- 1, Proposed floor; 2, Present ground line; 3, Single block weighing 60 tons; 4, Two weighing 65 tons each; 5, Oak stumps on end with band; 6, Two blocks of 75 tons each; 7, Oak baulks crossed; 8, Three blocks.

produce a perfectly even surface for the baulks of timber which come next. These were of oak, thirty feet long, and a foot square. Upon the baulks of oak rest two more plates of cast-iron, twenty-seven feet long, and thirteen feet six inches wide, and weighing each seventy-five tons. They are connected by huge dove-tails cast into the metal itself, as are also the two lower ones, and all the other plates which are in the same horizontal plane. A liquid called "grouting," formed of very thin watery concrete, is poured in between the joints of the plates so as to fill up all interstices, and holes are made in several places through the castings, so as to admit of the grouting freely percolating everywhere. Upon the two plates are more planks of rock-elm, and then a layer of oak stumps two feet three inches long, placed upright, and surrounded by a band of wrought-iron, six inches wide by two inches thick. All the remainder of the foundation pit was filled in with concrete as the work gradually proceeded upwards. Upon the oak stumps are two plates,

weighing each sixty-five tons, and forming a square of twenty-four feet. A thin layer of rock-elm planks separates them from a huge single casting, twenty-two feet square, and weighing very nearly 100 tons. Wedges within the joggles of the 65-ton plates fix firmly the single one above, and it in its turn supports the enormous anvil block weighing 103 tons, over which will come the anvil itself, but that is not yet in position. The anvil block was cast in a closed mould, which rested upon a substratum of coke and bricks with passages left filled with straw for the exit of the gas generated; it took, nevertheless, *six months* to cool, and could not be removed until after the manufacture and removal of several subsequent castings. Such is a short review of the principal features in the construction of these foundations; all other information as to details in dimensions, &c., may be obtained from the accompanying engraving. About 660 tons of metal have been made use of in completing them.