1960"), and he derived statistical measures devised to quantify the relationship between changes in export and money incomes.

The concept of the African personality was presumed to have a social significance by Cleo Kumalo ("Toward a Sociological Approach to the Concept of the African Personality"), and he went on to raise the basic question of whether and how that reference can be discovered through the logico-experimental method of science. In his topical talk, Donald S. Rothchild ("Progress and the One-party State") concluded that the evidence for a correlation between political processes and economic progress is neither complete nor convincing. R. C. Bridges ("Are Explorers Redundant in East African History?") asserted that impressions given in Europe by explorers' exploits created a "frame of reference" within which missionaries and administrators worked, and in this way explorers' work is, indeed, a factor in the history of East Africa. Another topical talk was that given by A. K. Mayanja ("The Rule of Law in Emergent African States"), who recommended that both the formal and metalogical aspects of the rule of law need to be insured against legislative erosion.

Jonathan Silvey ("Formal and Informal Learning through the Medium of a Second Language") considered

Bernstein's concept of public and formal (or individualized) language in relation to the language modes characteristic of rural and educational life in East Africa. These meetings were ended by J. Kariuki ("Poetic Works") reciting a number of his own poetic works.

The proceedings of the entire symposium are to be published. This is just one of the many decisions made at the annual general meeting and the meeting of the Executive Council. Others are the decision to hold the next symposium meeting in Nairobi next May; the appointment of several standing committees (Research and Studentships, Conferences and Liaison, Editorial and Symposium, Education, and Membership); collaboration with the Ghana Academy of Sciences in bringing to fruition the *Encyclopaedia Africana* project; decision on the principle of admitting societies operating within East Africa to institutional membership; and plans for bringing about the formal recognition of the Academy as their national academy by the East African Governments. Dr. N. C. Otieno, lecturer in botany, Royal College, Nairobi, was elected president of the Academy, Dr. J. Njoroge (plant pathologist, Scott Agricultural Laboratories, Kabete), secretary, and Mr. M. Alala (lecturer in mathematics, Royal College, Nairobi), treasurer.

THOMAS R. ODHIAMBO

THE DELHI PILLAR

THE mystery which has enveloped this quite remarkable piece of metal should be once and for all removed as a result of three papers published in the February issue of the *Journal of the National Metallurgical Laboratory of India* (5, 24; 1963). All that has been previously written is summarized and the theories propounded to explain its resistance to corrosion are collected. Despite efforts by M. K. Ghosh and by Lahiri, Banerjee and Nijhawan to support the view that there was something about the manufacture of the metal which endowed this remarkable forging with special resistance, there can be little doubt that Bardgett and Stannors's conclusions deserve acceptance.

Made by hammer-welding small balls of native iron of a fairly wide range of carbon contents, its resistance to corrosion during the 1,600 years or so of its existence is ascribed to the combined influence of a number of normal, favourable factors. Among these are included the climate and freedom from pollution of the atmosphere which exceeds Vernon's critical humidity of about 80 per cent for less than 5 per cent of the year. Secondly, to a progressively decreasing rate of attack due to the building up of a protective layer of oxide and scale during the early years of exposure.

That in the past on ceremonial occasions the pillar was anointed appears to be probable, while even to-day it is repeatedly handled. This is supported by the X-ray analysis of a minute sample of the surface coating about 5 ft. above the base which contained no iron and only

quartz and chalk providing another source of protection. The authors conclude, and it is impossible to disagree with them, that "It is evident that a number of favourable factors have been acting simultaneously and the sum total of the information leads to the view that, although one may justly admire the skill and technology of the early Indian ironworkers in producing so large a monument, there is no reason for surprise at the longevity of the pillar. The composition and structure of the iron or its method of manufacture can only have contributed in a minor degree to its preservation and are in no way essential for this. The present authors, indeed, are as confident as one can be in such matters that, given the same circumstances and environment, a pillar forged from modern tonnage steel would, after 1,600 years, have been practically as preserved". Coming from men of such experience and in view of all the evidence here set out, it is impossible to disagree with this view.

The other two papers also discuss the technological aspects of ancient iron-making in India and confirm the account given in Percy's book on iron and steel of a hundred years ago. In particular, they refer in some detail to the iron beams at the Sun Temple of Konarak which show similar resistance to corrosion to the Delhi pillar despite the fact that they are situated on the sea coast. Lahiri, Banerjee and Nijhawan's insistence on the protective influence of envelopes of slag around the metal may here have exercised a decisive influence.

F. C. THOMPSON

RECOGNITION OF SEDIMENTARY ENVIRONMENTS

FOR more than a century geologists have striven to discover criteria by which the environment of deposition could be inferred from the characteristics of arenaceous rocks. Concentration on one or another aspect has changed over the years, providing a mass of data which have underlined the breadth of the problem without providing a simple solution.

Investigations of the particle size distribution of modern sediments have shown that many environments can share similar distributions, while work on the hydraulic aspects of particle transport and deposition has failed to explain

the complex nature of many natural sediments. For some years there has consequently been a tendency to rely less on granulometric analyses and more on forms of bedding, such as ripple marks, laminations, and other small sedimentary structures. But here also there are hints that few, if any, of the supposedly diagnostic features are unique to any one environment, and the feeling is gaining ground that the environment in which a given sample was deposited can only be deduced reliably by considering the complete suite of associated sediments.

Some renewal of hope that at least wind-laid, water current-laid, and wave-laid sands and gravels can be differentiated by an examination of the size and shape relations of the particles in a small sample is offered by A. J. Moss ("The Physical Nature of Common Sandy and Pebbly Deposits. Part II": *American Journal of Science*, 261, 297; April, 1963). Because the stability of a particle on a bed depends largely on the effects of neighbouring particles, it is shown that there is a strong tendency for grains of similar size, shape, and density to accumulate together from a saltating traction load. The resulting population may be accompanied by a population of particles small enough to reside in its interstices, and one

of particles large enough to be slid or rolled over its surface. The relative abundance of these populations, which can be recognized in modern and fossil sediments, forms the basis of interpreting the environment.

Extensions of the idea help to explain many peculiarities of natural deposits, such as the formation of heavy mineral concentrates, the abrupt changes in texture of adjacent laminae, and the simultaneous accumulation of particles of widely differing size. They also explain the failure of granulometric analysis, as usually carried out, and provide a unifying link between the textural and structural approaches to the problem.

J. C. M. TAYLOR

ESTIMATION OF RUBY LASER OSCILLATION LOSS

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LASER action in a pulsed system requires that during the pump cycle a population inversion be attained which is sufficient to provide enough gain per optical transit to overcome the various losses of the loaded laser enclosure. In addition to end-wall transmission losses, which are accurately known from end-reflectivity specifications or direct measurement, there are also internal oscillation losses in solid laser media caused primarily by scattering, non-resonant self-absorption, end-wall absorption and scatter, and crystal non-uniformities, none of which is directly measurable.

The two principal effects of internal losses are an increase in threshold pump power for onset of oscillation over predicted values and a decrease in output energy above threshold. The latter is dramatically indicated by the ruby laser output shown in Fig. 1 (ref. 1), where the Q or internal radiation lifetime of the laser enclosure is made greater by increasing end reflectivity r from a low value while the pump energy pulse remains unchanged. From energy considerations, we would expect to see no decrease in integrated output energy under these conditions in the absence of internal loss mechanisms. Therefore, the observed reduction in output is evidence of significant loss per transit, enhanced in this example by the effective increase in the number of transits as r is increased.

It was found practical to examine internal losses by investigating conditions at threshold, since this specialization eliminates from the problem well-known uncertainties in measurement and interpretation of output power. The estimate of the degree of internal loss is accomplished by comparison of experimental results with theoretical curves. From the point of view of a mathematical model, threshold is defined by use of a step function optical pump input to a population rate problem that is based on an idealized ruby energy level system. Threshold pump power, then, is a step function in time of photon flux density or of pump transition probability sufficient to produce a steady-state population inversion ΔN that satisfies an oscillation condition of the form $\Delta N l \sigma = \ln r$, where σ is the cross-section for the laser transition and l is the optical path-length between reflexions characterized by r . Similar mathematics with only slight variation in assumptions have appeared in detail previously²⁻⁵. Therefore, only the particular assumptions and solution employed here are stated.

A four-level ruby system is assumed in which atoms excited by pump photons from the ground-state to absorption bands rapidly decay non-radiatively to the metastable R_2 and R_1 levels ($\nu_{R_1 R_2} = 29 \text{ cm}^{-1}$), which, in turn, rapidly thermalize to a Boltzmann distribution. These two processes are so fast compared with the reciprocal of the pump transition probability or the R level

lifetime that a pump photon absorption is assumed to excite a ground-state chromium atom directly to one of the R levels. For the low-temperature limit of interest in this article, $\sim 150^\circ \text{C}$, the Boltzmann distribution of the closely spaced ground-state levels is taken as equal. Since small ΔN threshold conditions prevail, the only laser transition considered is from the level R_1 to the ground-state, and the only loss assumed from the excited state prior to laser action is by unamplified spontaneous emission. The variations of the laser transition line width $\Delta\lambda$ with temperature and R level Boltzmann distribution are the only temperature dependencies considered. In addition, we make the assumption that the laser medium is optically thin, or that the pump photon flux is uniform in the sample. These assumptions yield the following solution for ruby threshold power versus reflectivity and temperature T :

$$P_{\text{rel}} = A \{ [1 + \exp(42/T)] - 2 \ln r \} / (2A + 2 \ln r) \quad (1)$$

Fig. 1. Ruby laser output for various fixed values of input energy