Recently, Great Britain honored the memory of Sir John Murray by a "John Murray Expedition" to the Indian Ocean. It appears to me that the best manner in which the United States can honor the memory of Alexander Agassiz will be to organize a large-scale Alexander Agassiz Expedition for exploration of the Pacific Ocean.

HARALD ULRIK SVERDRUP

THE CHANGING OUTLOOK OF ENGINEERING SCIENCE[1]

By Professor R. V. SOUTHWELL

PROFESSOR OF ENGINEERING SCIENCE, UNIVERSITY OF OXFORD

BRIEFLY, here too my thesis is that we should avoid undue humility! The times are out of joint, and having attained to command of nature greater than the world has seen before, because man has not learned to use his mastery wisely, illogically now (as it seems to me) he inclines to question the value of that mastery, and the labors that have given it. In particular I want to record my protest against what seems to be an implication in much that is written nowadays, that because the range of engineering includes guns, battleships, aeroplanes, tanks, therefore engineers are to be regarded as a class more than others responsible for the horrors of modern war.

Here are words spoken by Sir Alfred Ewing, in a presidential address to the association (1932) which I keep to read ever and again, for its showing of what at the best an engineer's outlook may be:

> An old exponent of applied mechanics may be forgiven if he expresses something of the disillusion with which, now standing aside, he watches the sweeping pageant of discovery and invention in which he used to take unbounded delight. It is impossible not to ask, Whither does this tremendous procession tend? What, after all, is its goal? . . .
>
> The cornucopia of the engineer has been shaken over all the earth, scattering everywhere an endowment of previously unpossessed and unimagined capacities and powers. Beyond question many of these gifts are benefits to man, making life fuller, wider, healthier, richer in comforts and interests and in such happiness as material things can promote. But we are acutely aware that the engineer's gifts have been and may be grievously abused. In some there is potential tragedy as well as present burden. Man was ethically unprepared for so great a bounty. . . . The command of Nature has been put into his hands before he knows how to command himself.

Here too are words spoken somewhat earlier, in his wonderful James Forrest Lecture, 1928, on "A Century of Inventions." In them still more clearly, as I read them, he seems to feel as engineer a sense of special responsibility:

> I used, as a young teacher, to think that the splendid march of discovery and invention, with its penetration of the secrets of Nature, its consciousness of power, its absorbing mental interest, its unlimited possibilities of benefit, was in fact accomplishing some betterment of the character of man. . . . But the war came, and I realized the moral failure of applied mechanics. . . . We had put into the hand of civilization a weapon far deadlier than the weapons of barbarism, and there was nothing to stay her hand. Civilization, in fact, turned the weapon upon herself. The arts of the engineer had indeed been effectively learnt, but they had not changed man's soul. . . .
>
> Surely it is for the engineer as much as any man to pray for a spiritual awakening, to strive after such a growth of sanity as will prevent the gross misuse of his good gifts. For it is the engineer who, in the course of his labors to promote the comfort and convenience of man, has put into man's unchecked and careless hand a monstrous potentiality of ruin.

To which I personally would answer: "Yes, for the engineer as much as any man, *but no more.*" And when, in more recent pronouncements, I find the charge so glibly formulated—"It is engineers who have given men these potent weapons of destruction: on them *more than others,* then, rests the responsibility for their use"—then, admitting the premise, I protest against the deduction. I would say rather: "On them as much as on others (but no more) rests the responsibility for their use." Do not think that I imagine the load thus shared will be light for all. I have no illusion about the weight of responsibility—it is appalling; but I hold that we must share it equally, as citizens, not look for scapegoats when we have been free either to choose our path or leaders to direct us.

I can conceive no subject in which, more than this, clear thinking is wanted to-day: the desire to hand on responsibility is so deep-seated, and the will to believe that we could have had the benefits of science without its risks and its temptations. But knowledge is of good and evil: it is of its essence that we can not know how to cure poison without knowing poison and its action, how to control and use explosives without acquiring power for harm as well as good. We may elect either to shun it or pursue, but we can not have it both ways. Either we must choose, deliberately, impotence as preferable to the power of doing evil, or we must accept knowledge for the double-edged tool it is, vowing to use it wisely. We may not say to the scien-

[1] The concluding portion of the address of the president of the Section for Engineering of the British Association for the Advancement of Science, Cambridge, 1938.

tist, "Keep searching, but let your discoveries be such as must benefit and can not hurt us"; or pretend that the use we make of science is something outside our responsibilities as citizens, a thing imposed upon us by science itself. *Knowledge is not moral:* good and evil are its opposite sides, inseparable in its very nature. I have no quarrel (though no sympathy) with the plea we sometimes hear, for a cessation of scientific activity: it is arguable that on balance knowledge is undesirable. But when men talk of "beneficent" and "destructive" science as though we were free to pick and choose, then I say that they have not even begun to understand what science is.

Holding these views, I find it matter for regret that so often our concern with the impact of science on the life of the community, which is good and healthy, is expressed in a manner that is neither. Too often we seem to be weakly apologizing for results that have followed our activities, as it were because we did not take sufficient care. Need the geneticist apologize for having increased the earth's fertility, because we have found no better use for plenty than to destroy food while thousands are in want? Ought doctors to regret that by coming to a fuller understanding of disease they have lengthened the span of life in a world where birth rates are falling? Here and in countless other instances, science impinging on the life of the community has set problems that will tax to the utmost its courage and intelligence; the hardest and clearest thinking will be wanted, and it is right that engineers and scientists should seek to contribute their share. But I think that we only confuse the issue when we intervene *as specialists* in discussions which concern us really not as specialists but as members of a community.

Whether in these days, when all but a small minority seem convinced of the necessity of rearmament, the engineer is still regarded as scapegoat or has (for a time) been transferred to the rôle of savior, I have no means of judging. But if any still reproach him for making what all men now seek to buy, I would answer that horror is not peculiar to modern war; all war is horrible, both in nature and by purpose, and wars are made not by engineers but by communities. No war is righteous, though it seem so at the time; or inevitable, except as a penalty of national sins: pride, greed and indolence; and those more contemptible because weaker sins, vacillation of purpose, persistence in shams, clinging to safety even at the loss of honor.

More and more frequently, in lectures and in editorials, the decline of international standards is noticed with consternation and lament. Naturally, perhaps, in this country we are apt to see it mainly as an increasing tendency towards "repudiation of law and order in favor of brute force,"[2] revealed most clearly in states that have abjured the democratic ideal. But I think that the malady is at once deeper and more general. Dare we claim that our own policy has shown no falling away from earlier belief in straight-dealing, generosity and the sanctity of contracts?

Increasingly, as it seems to me, nations incline to put trust in the adroitness rather than the sincerity of their statesmen. Ethics are out of fashion, and while as individuals we may still admit the moral imperative, the notion that motives recognizable as moral can have place in international affairs seems now to be rejected as impracticable idealism. Force and deceit, it appears, although unpleasant are held to have "survival value": the gangster compels our unwilling admiration, at least in the field of world affairs. But what if there should be something in the notion, that because success in the life-struggle can come not only by individual strength but also by ability to associate and combine, morality has survival value as being (thus regarded) one of the factors which make association possible? A bank may come to ruin not only through fraudulent or incompetent direction, but because its depositors, panic-stricken, seek each his own legitimate interests at the expense of the common weal: may not a less narrow concept of moral obligation be necessary to the continuance of our civilization, even as wider than national horizons are necessary in the spheres of economics and finance? Perhaps this "idealism" is not so impracticable after all?

Collective security attained by higher standards of fair dealing—it is an epitome of man's progress from the cave to association in the village, in towns and in nations, and I see no ground for believing that the notion can never transcend national barriers. Men write as though it were new—a product of post-armistice utopianism. That it is not new let these sentences, none written less than 100 years ago, bear witness (Guedalla, 1931):

> Soyez sur qu'en politique il n'y a rien de stable que ce qui convient aux intérêts de tout le monde; et qu'il faut regarder un peu plus loin que soi-même.
>
> . . . although the aggrandizement and security of the power of one's own country is the duty of every man, all nations may depend upon it that the best security for power, and for every advantage now possessed, or to be acquired, is to be found in the reduction of the power and influence of the grand disturber.
>
> If we lose our character for truth and good faith, we shall have but little to stand upon in this country.
>
> I would sacrifice Gwalior, or every frontier of India, ten times over, in order to preserve our credit for scrupulous good faith, and the advantages and honor we gained by the late war and the peace. . . . What brought me through many difficulties in the war, and the negotiations for peace? The British good faith, and nothing else.

If this be utopianism, then some of our historical

[2] Vide *Nature,* May 28, 1938.

judgments will need revision; for all were said or written by Arthur, Duke of Wellington—a man not lightly to be charged with saying what he did not mean.

You will say, now I am drifting perilously near to politics! It is precisely the point I want to make: I say that inevitably, when instead of science we discuss its impact on the life of the community, we *must* verge on politics, because what concerns the community *is* politics, both etymologically and in fact. The old convention, that science should have no politics, seems to me sane and wise: how to preserve it if as scientists we are to concern ourselves with the life of the community, that is a question I must leave to others more subtly-minded. For myself I see no reason why as scientists we should meet to discuss anything but science. Contrary to common belief, it is not our habit to pursue science throughout the whole of every day; and on all counts I hold it were better that we came to political discussions in hours of leisure, unlabelled, than give support to a notion that political problems will yield to something known as "the scientific attack." Talk to me of the scientific approach in physics, and I shall have an idea of what you mean, though you will easily bewilder me with detail: talk to me of "scientific approach" to problems of real life, I shall suspect you of indulgence in mere jargon.

This is not to assert that science unfits a man for political discussion: if only because by training men of science are prepared to believe that problems of urgency may yet be hard, I hold on the contrary that some scientific leaven is beneficial in almost any body of administrative humanists. It is a protest against our facile modern use of the word "scientific" (which if it means anything connotes a special kind of approach to special problems) where "trained common sense" is the faculty which is really needed. In science we seek to explain phenomena which we believe to be outside man's control: it is the faith in which our work is done—for if the facts were not inexorable, and could be altered at man's pleasure, how could we hope to find enduring "laws"? But politics is concerned with action in fields where we believe that we can influence results: I see no reason to believe that the same technique will serve.

Rather than seek to defend our activities from the charge that evil can come of knowledge misapplied, might it not be better that we undertook a harder task, trying to instill into the mind of the public a clearer notion of the aims with which real scientific work is done? For what is that notion now, in these days of "popular science"? At best, a picture of life lived monastically by men who care nothing for the world outside their laboratories, but spend their energies unceasingly in the quest for more and more knowledge of less and less. (Is it surprising if the public question the right of such men to leisure, seeing that by their carelessness, as it appears, forces are unleashed which may bring our civilization to utter ruin?) At worst, an uncomprehended picture of modern "wonders of science"—gifts which these same men have conferred upon their fellows, altruistically wrestling from nature the secrets of spiritual and material benefit; so that somehow, while the astronomer fosters humility by telling the vastness of interstellar space, Heisenberg's principle of determinacy is thought to bring mystic comfort to men oppressed by the notion of all-pervading law. Equally unfounded, it is, I believe, the other side to that sense of responsibility for the consequences of science, about which I have spoken already; and on a more material plane it is the mainstay of the patent medicine business! For it has given us a public superficially acquainted with "recent progress in science," yet in reality no less ignorant, and more gullible, than was the public of Victorian days.

Never have greater powers of exposition been devoted to the "popularization" of science: when, I wonder, shall we find like powers devoted to the harder task of a real *apologia*? To telling, not of the treasure found, but of the quest; to showing the true man of science (for it is the fact) neither as care-free *dilettante* nor as philanthropist, but seeking truth like the artist, because he must? That, I maintain, is the real spirit of science, be it pure or applied; a spirit that breathes in every book of science worth the name: to make of difficulty a stimulus, to be unwearied in determination to do good work. Is it not there, rather than on a favorable trade-balance of benefits conferred, that we who have chosen science should stand in our defence? Were it not better that the public be told plainly: This is our work, which we do because we must?

A lead has been given, and we may be proud that the giver was an engineer; for the gleam is seen in that noble presidential address by Sir Alfred Ewing from which I have quoted already:

> The quest of truth goes on endlessly, ardently, fruitfully. And yet with every gain of knowledge we realize more clearly that we can never really know. To understand, as Einstein lately said, is to draw one incomprehensible out of another incomprehensible. From time to time we discover a fresh relation between observed phenomena, but each of the things which are found to be related continues to evade our full comprehension; and that is apparently the only kind of discovery we can achieve. Our joy in the quest itself never fails; we are constantly learning that it is better to travel than to arrive.

That I say is the spirit! Let us have the courage of the artist to exalt our calling, and while deploring

the folly that has led us and other men to misuse them, let us not weakly question that the gifts of science hold potential good. Fairly regarded, the record of engineering is not such that we need feel ashamed of our calling. Again, to quote Sir Henry Tizard (1938):

> There is nothing new in the fact that experiment and invention are transforming the habits of men and are adding to their problems. What is new is that we are all more aware of it, because the rate of change has been steadily increasing. . . . Bad news is, as a rule, better copy than good news. But can it seriously be argued that any section of society is worse off and living under worse conditions than a hundred years ago? Broadly speaking, the natural result of all scientific discovery has been greatly to improve the conditions of life and all our social relations, in spite of—or possibly even because of—the fact that scientific workers have been too busy doing their own jobs well to worry about other people's.

So Dr. Johnson to Mr. Boswell: "My dear friend, clear your *mind* of cant. . . . You may say, 'These are bad times; it is a melancholy thing to be reserved to such times.' . . . You may *talk* in this manner; it is a mode of talking in society: but don't *think* foolishly."

SCIENTIFIC EVENTS

SCHOLARSHIP AWARDS OF THE CANADIAN NATIONAL RESEARCH COUNCIL

THE National Research Council announces that forty-one awards of scholarships have been made for 1939–40. These scholarships form part of the means by which the council stimulates postgraduate training and scientific research in Canada. The successful candidates this year are drawn from fourteen Canadian universities. One of the candidates will study dairy bacteriology at the National Institute for Research in Dairying at Shinfield near Reading, England; all the others will carry on postgraduate research at Canadian universities. Three holders of special scholarships will be in training at the National Research Laboratories in Ottawa, where they will acquire experience in the study of industrial and commercial problems. Two of these scholarships have a value of $1,000 each and the other one is worth $750; four fellowships at $750 each and thirty-four studentships at $650 each are tenable at the universities.

Of the successful candidates for awards twenty will work in the field of chemistry, eight in physics, two in geology and one in engineering. In the biological sciences two will work in bacteriology, one in entomology, one in plant biochemistry, one in genetics and cytology, two in general biology and three in biochemistry.

In addition to the fellowships and studentships announced above provision has been made for a number of bursaries at $250 which are to be held under cooperative arrangements between the National Research Council and the universities in which the graduate students will be enrolled. Particulars of these further awards will be announced at a later date.

THE PERMANENT SCIENCE FUND OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES

INCOME from the Permanent Science Fund, according to agreement and declaration of trust, shall be applied by the American Academy of Arts and Sciences to such scientific research as shall be selected ". . . in such sciences as mathematics, physics, chemistry, astronomy, geology and geography, zoology, botany, anthropology, psychology, sociology and economics, history and philology, engineering, medicine and surgery, agriculture, manufacturing and commerce, education and any other science of any nature or description, whether or not now known or now recognized as scientific, and may be applied to or through public or private associations, societies, or institutions, whether incorporated or not, or through one or more individuals."

Applications for grants under this indenture are considered by a committee of this academy on stated dates only. The next meeting to consider applications will be held on October 1. Applications should be made on special forms furnished by the committee. Correspondence, including requests for application blanks, should be addressed to the chairman of the Committee on the Permanent Science Fund, Professor John W. M. Bunker, Massachusetts Institute of Technology, Cambridge, Mass.

Grants-in-aid from this fund were voted by the academy on April 12, 1939, as follows:

To Professor Emil Bozler, of the department of physiology, the Ohio State University, for the purchase of apparatus to be used in a study of action potentials of smooth muscle, $250.

To Dr. Donald E. Cameron, professor of neurology and psychiatry, Albany Medical College, for the purchase or construction of apparatus, as specified, to study the change in response to repetition of an unpleasant situation in psychotic patients, $200.

To Professor William H. Cole, department of physiology and biochemistry, Rutgers University, for technical assistance, materials and special apparatus for the determination of the chemical composition of the bloods of invertebrates, $500.

To Professor Robert S. Harris, department of biology, Massachusetts Institute of Technology, for the purchase of a newly developed instrument for optical quantitation of vitamin B_1, for a study of the daily requirement of