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The Heavens are Telling

By EDWIN B. FROST

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Professor Edwin B. Frost is one of the leading astronomers of the world. He has been Director of the Yerkes Observatory of the University of Chicago since 1905; has been Editor of the "Astrophysical Journal"; Member of the Royal Astronomical Society; National Academy of Sciences; American Academy of Arts and Sciences; Vice-President, American Association for the Advancement of Science, 1912. He has published much material in the field of his science.

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"THE HEAVENS ARE TELLING"

EDWIN B. FROST

The spectacle of the starry heavens is the privilege of everyone who has eyes with which to see. It is only necessary to escape from the glare of artificial light which modern civilization finds needful for its streets and public places. In the quiet of the country, or on the upper deck of a steamer, or, best of all, from the vantage of a mountain peak, we can obtain without instruments and without guidebook, if the night be clear and if there be no moon, a view of the richness of the stellar heavens which well repays the slight effort required. If it is a transparent night, the eye beholds the stars of many degrees of brightness and of varied shades of color, shining steadily from above and twinkling near the horizon, while some brilliant planet with serene radiance may be a dominant factor in the scene, or as Milton says:

. . . . now glowed the firmament
With living sapphires; Hesperus that led
The starry host rode brightest.

Athwart the arch of the heavens will appear the soft outline of the Milky Way,

> Which nightly as a circling zone thou seest
> Powder'd with stars.

This scene is one of beauty not soon to be forgotten. Such a view can hardly fail to inspire in the observer a feeling of wonder and of worshipful admiration of this partial exhibit of the external universe.

If the watch of the glittering sky is maintained for some time, or repeated at a later hour, the stately motion of the stars becomes apparent as our planet turns beneath them. Such views, as we have said, are the heritage of all who will take them, and have been shared alike by the untutored savages and by those of cultured mind since human eyes first began to look upward. The pleasure is the greater for those who have often watched the stars and have come to know the constellations, so that each hour of the night brings new but familiar stellar friends into view. It cannot be questioned that every increase of our appreciation of the creation must en-

hance our respect for its Creator. It is equally clear that the expansion of our knowledge, due to deeper study with the use of powerful instruments and a better interpretation of the significance of what we see, can only add reverence to our respect. As was said by the philosopher Kant, one of the first to formulate a theory of the development of the solar system,

> Two things there are that inspire wonder and constantly increasing reverence the oftener and the more they are considered—the starry heavens above me and the moral law within me.

The marvelous photographs which are now being obtained reveal a wealth of celestial splendor that is almost appalling. Interpretation is necessary to understanding, and we shall try to give an idea of the enormous span of the material universe, of the immense number of luminous objects it contains, and of the vast reaches of time which are required for their development.

The brightness of the stars gives us no certain indication of their distance. This must be determined by the most precise of measurements made with the most powerful of instruments. The stars

differ in their glory because some are enormous giants while others are dwarfs like our sun. Some are white stars with intensely brilliant surfaces, while others are ruddy, with fading radiance. Some are known to be non-luminous—relatively if not absolutely dark.

Our ideas of size may be quite incorrect. The sun and the moon, for example, appear to be of the same size in the sky, but the proper measurements show that the sun has a diameter 400 times that of the moon. Because it happens to be also 400 times as far away, it presents the same angular diameter to the eye. We, of course, recognize that the sun is very much brighter than the moon; we should hardly guess what the measurements show, that it is more than 500,000 times as bright. Our interpretation of what we see must therefore always be dependent upon most patient and minute measurements extending over long periods of time.

As our appreciation of the sizes and distances in the universe has increased, new units of length, mass, and time have to be employed to express the vast quantities in question. It was once the

custom, and still is in some parts of the world, to state the distance between two points on the earth by the time it would require to walk that distance. Thus, a Swiss native will tell you that it is two hours to the next village. In astronomy we have to adopt similar expedients for giving the idea of the immense distances involved. It is hardly possible for us to grasp the significance of such a moderate distance as that from the earth to the sun, often taken as the unit of length in measurements of the solar system. That it is 93,000,000 miles means little, for few of us can appreciate the quantity known as 1,000,000. Let us try to realize how enormous this system is by the use of a modern illustration:

The speed of 100 miles an hour is not uncommon for an airplane. Suppose, then, that some tireless aviator in a machine carrying an inexhaustible supply of fuel could fly on without stop at this rate. Hurrying on by day and night, he would pass around the earth at the Equator in 10 days, traversing 2,400 miles per day. If we now suppose that his machine could fly across the vast airless space beyond the earth's atmos-

phere at the same speed, he would reach the moon, the earth's little brother, in 100 days, but to arrive at the sun, our aviator would need also the gift of perpetual youth, for at this constant speed of 100 miles per hour, 106 years would be required to reach the sun. The planet Saturn would be passed in 1,000 years, and Neptune, which is at the frontier of the solar system so far as is known at present, would be attained in 3,000 years of ceaseless flight. Leaving the solar system, our imaginary aviator would now begin his real passage through the desert waste of space, and it would take him 27,000,000 years to reach our nearest stellar neighbor, the system of Alpha Centauri. To cross this stretch of void, the swift rays of light require $4\frac{1}{3}$ years.

For stellar distances the unit known as the light-year has been found to be most convenient. It is the distance that light would cover in a year traveling in empty space at the uniform speed of 186,000 miles per second, or 11,000,000 miles per minute. This unit is 63,000 times the astronomical unit, or the distance from the earth to the sun; the

light-year is, in fact, only a little short of six million million miles. Only 500 seconds are required for light to pass from the sun to the earth; it would take light to reach us from Neptune slightly more than 4 hours; from the nearest known star, $4\frac{1}{3}$ years, as mentioned above; from the average star visible in a small telescope, about 800 years, or, in other words, the distance would be 800 light-years. Our whole conception of the scale of the sidereal universe has increased very greatly since the beginning of the present century. Previous to that it had been possible to measure with accuracy the distance of hardly more than a dozen stars; now we have fairly reliable determinations of the distances of several thousand.

Careful investigations have recently been made which show that, counting our own sun as one and at the center, there are only 105 stars situated in an imaginary sphere in space having a diameter of 65 light-years. This illustrates the enormous vacant spaces around each star.

Although the stars may seem innumerable to one who is looking upon

them on a perfect night from a well-chosen station, yet, as a matter of fact, hardly more than 2,000 are thus visible to one person at any one time. The fainter stars are vastly more numerous than those seen by the naked eye. In fact, only one-twentieth of the starlight which may guide the wayfarer at night is due to the stars which he can see; nineteen-twentieths of the illumination is due to stars too faint to be seen as such. Estimates of the total number of stars must necessarily be very uncertain, and allowance has to be made for those which are beyond the reach of our present telescopes, but the evidence is that *they are not infinite in number*. A recent estimate has placed the number of luminous stars at about fifteen hundred million; several million have already been catalogued on the photographic charts of the heavens.

Let us now consider the dimensions, and qualities of a star, taking our sun as an example, although it is smaller than the average star. It contains over 300,000 times more matter or mass than the earth, and its volume or bulk exceeds that of the earth more than 1,000,000

times; in other words, over 1,000,000 planets like our earth could be put inside our sun. It emits heat as would a perfectly radiating surface at a temperature of about 11,000° F., but in the interior its temperature may reach several hundred thousand degrees. The continuous radiation from a square yard of the sun's surface expressed as power is about 1,000,000 horse-power. This is vastly more than could be produced if the sun were of the best coal burning in pure oxygen. In fact, the temperature of the sun is so high that there could be no burning or oxidization. The source of the sun's heat and its steady maintenance are not yet fully understood. If a gaseous ball like our sun contracts, as it must under the enormous pressure of its own gravitation, which is twenty-seven fold that at the earth's surface, then the present supply of heat resultant from this continuous compression would last perhaps for 50,000,000 years, but the geological evidence indicates that one thousand million years or more are required for the development of our earth to its present condition. This is from twenty to fifty times the time avail-

able on the contraction theory. New discoveries of radio-activity suggest new sources of heat from the transformation of the elements in the sun, which are probably adequate for its maintenance for as many billions of years as may be required. The sun's material is chiefly or wholly gaseous with an average density not twice that of water; it contains vast amounts of vapors of iron and of metals familiar on the earth, together with enormous amounts of permanent incandescent gases like hydrogen and helium. In fact, about one-half of the elements found on the earth have already been demonstrated by the spectroscope to be present in the sun; the others are doubtless there, but are not brought out under the conditions of the sun's radiation.

We have thus tried to give an idea of the immense scale of our sun and of its characteristics; but we must remember that it is less than an average star. It has been found, however, that the mass in the stars is not so much greater than that of the sun, but the size and hence the volume may be vastly greater. Thus, recent measurements of the diame-

ters of a few of the stars have indicated that such stars as Betelgeuse and Antares have a bulk of from thirty to forty million times that of the sun! Other stars vastly exceed our sun in brilliance; thus Rigel, one of the glories of the constellation of Orion in the winter sky, would be at least ten thousand times as bright as our sun if we could come as near to it as we are to the sun.

The spectroscope, one of the magic instruments of modern research, spreads out the light of a star into a band of color with red at one end of the band, violet at the other, and myriad hues between. There are gaps in the band, some very narrow and some broad, which are called the lines of the spectrum and which teach us many important things about the physics and chemistry of the stars. When photographs of these stellar spectra are compared with each other, it is found that they may be arranged in a long series merging from one into the next, and representing successive stages of the evolution of the stars. These changes must occur in general very slowly, requiring periods of

time far beyond any possibility of record in the lifetime of a race, but we may be as confident of the progress of the stars' evolution as a child at an early age is certain that human beings pass through various stages of life from youth to age; the child realizes that these changes must occur although he has not lived long enough to see them. There are many points in stellar evolution which require for their explanation much more than our present knowledge, and, as a matter of fact, we are just now decidedly unsettled in our views as to the relation of the stars to the nebulae, but all the evidence points toward an orderly evolution of celestial bodies.

Much attention has been given in recent years to the globular clusters of stars. These are immense systems roughly spherical in their shape, containing vast numbers of brilliant suns. They appear in the telescope so crowded that they overlap each other and become a hazy mass in the central portion. In reality they must be billions of miles apart, although clearly members of one relatively compact system in which the movements of each is under the gravita-

tional control of all. There may well be a million stars in the great cluster in Hercules, which is faintly visible to the naked eye as a little patch of hazy light. Fairly accordant estimates of the distance from us of these clusters made by different methods place the nearer of these remarkable objects at a distance of some 20,000 light-years, and the more remote at some 200,000 light-years. In other words, if a star in one of the more distant clusters should suddenly explode, 200,000 years would be required for the rays of light to bring us the visible news of that catastrophe. The fact that there is no great difference in the conditions in the nearer of these clusters as compared to those most remote shows that their development proceeds very slowly, requiring periods of time almost beyond our imagination. We can sweep over vast periods of time as well as depths of space.

There is another class of celestial objects which are of the greatest interest and which have been studied in the last few years with success by photography. These are the spiral and spheroidal nebulae. Perhaps a million of them are

within reach of our present photographic telescopes. Estimates of their distance are very difficult to make, and vary greatly according to the method used, but it cannot be doubted that some of them may be a million light-years from us. One of these is visible to the naked eye as a fuzzy little spot in the constellation of Andromeda. It may be one of the nearest of the spiral nebulae. The spectroscope demonstrates that it is approaching us with a speed in the line of sight of one one-thousandth that of light-rays—that is, about 186 miles per second. If this speed and direction have been maintained for the past billion years, then this spiral has come nearer by a million light-years in that time. It is agreed among astronomers that there may be visible objects at a distance of a million light-years. This, then, may give us some little idea of the modern findings as to the scale of God's universe.

Can anyone doubt that the recognition of the immense size and detail of the celestial universe must give to all who consider it a new and larger idea of the Cause behind it? There is no adequate evidence known to the writer that the

universe is automatic, that it has within itself the power to make the laws which govern it. Mere matter cannot be imagined to be endowed with such capacity. The universe is a cosmos, as has been indicated in what we have already said, and from evidence which we shall cite farther on. It is not a haphazard aggregation of fortuitous and accidental bodies moving without system or order. It is perfectly true that we cannot comprehend in spite of all the efforts of science the whence and the whither or the why of all this. Nor is it to be supposed that these problems will ever be solved by the human mind. Each generation of students may contribute its little part, and sometimes the questions are pushed a little farther back toward the cause, but Omniscience would doubtless be required to understand the works of Omnipotence.

The thought may occur to some that in a universe on such a tremendous scale there would be no place for small objects, that the minute might be regarded as of no importance. The answer is that the laws of the universe apply equally to the almost infinitesimal parts, the molecule,

and the atoms of which it is composed, as they do to the gigantic bodies which it includes. The marvelous experimental researches in physics of recent years have taught us that the atom is a very complicated structure and that the electrons move within the atom somewhat as do the planets around the sun, and indeed with no greater crowding than occurs in the case of the planets; yet these inconceivably minute electrons follow the laws of the universe quite as truly as do the major structures. The Omniscience which we predicate can take within its ken the infinitesimal as well as the infinite. Does not this give us a more spiritual view of the Author of the Universe? It is so evidently "a house not made with hands"; it transcends so far anything that could be produced by any infinitely magnified model of the human form that we must recognize that only a spiritual power can lie behind it. It is not surprising that, in the dawn of civilization, men, in their very limited knowledge, imagined their Creator as merely a superman, to whom they attributed many of the faults of human nature, whose domain embraced only

that of their own tribe. Yet some of the writers caught at times the idea of the grandeur of the universe, as the psalmist when he said:

> When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained;
>
> What is man, that thou art mindful of him? and the son of man, that thou visitest him?

Now, although the earth is so insignificant and man and his works are so small, even in relation to the earth, it is interesting to consider what astronomy teaches as to the unity of the universe. Might we not expect that among the millions of suns we should find a great many kinds of matter representing thousands of chemical elements? We do not, however, find such variety, and the testimony of the spectroscope is sufficient. The atom of hydrogen is shown to be the same throughout the universe, and it is found in every self-luminous celestial object yet observed. Similarly, the atoms of the other elements do not vary from star to star. With only one or two exceptions, all the chemical elements are found on earth that are

known to exist in any of the celestial bodies. One exception is the gaseous element nebulium, which is a permanent constituent of one class of nebulae. It is still possible that this will be found on the earth, although there is no place for it in the present series of elements of the chemist. Perhaps it is not an element, but a combination of elements, a molecule. But aside from such exception, we learn that our sun is like the most distant star, and that our earth is chemically quite the same as the sun, and finally that our own bodies are composed of the more common elements of the earth. Thus, we may truly regard ourselves as samples of the whole universe. This may well give us the sense of a new dignity as citizens of the cosmos. We may even go so far as to think that the combination of spirit in material body such as we possess may not be of great variety, and that we may be not vastly dissimilar from beings which may inhabit other planets circling around their appointed suns. Science at present cannot either affirm or deny the existence of such planets; they are beyond the reach of modern telescopes. The largest planet

of our own system, Jupiter, would be wholly beyond detection with our telescopes from the distance of the nearest star. Our sun occupies no central or pre-eminent position among the stars—merely one of thousands of suns which seem to have passed somewhat beyond the middle point of their evolution. There is no logical reason to suppose that our sun is any better fitted to have planets about it than thousands of others, or that the planet earth should be highly exceptional. It is granted that mathematicians find great difficulty in understanding how a system of planets can develop around a star, but we know that such a system exists in the case of our sun, and it is difficult to believe that a similar development has not occurred for vast numbers of other suns. In the words of Pope:

He, who through vast immensity can pierce,
See worlds on worlds compose one universe,
Observe how system into system runs,
What other planets circle other suns,
What varied being peoples every star,
May tell why Heaven has made us as we are.

If it may be permitted to an astronomer to consider the social development of

the earth from a planetary standpoint, that is, as merely one of many presumptive planets with possible inhabitants, then we shall have to admit that this social evolution has been very slow, almost discouraging, in spite of all that Christianity has done for it. Paleontologists teach us that man has lived upon the earth for some 75,000 years. Nevertheless, one of man's chief occupations during much of this period has been to take from his neighbor, by force if necessary, even to the point of murder, that which he desires for himself. He has been suspicious of his fellow-men living in different parts of the earth with ways and habits unlike his own. He has had the strongest of prejudices against those who may differ from him in race and color. This is not a reproach to Christianity, for Christianity has been the principal cause of improvement in these matters. Nevertheless, collective murder is still current in the world, and it seems difficult enough to get rid of it. We can imagine planets that have developed otherwise, with brotherly love as the main motive in life, planets where the altruistic

principles of Christianity have reached a far higher development than here. But this is the only planet with which we can have any contact, so far as science foresees at present, and although we may be heartily ashamed that there is so much evil on the earth, we must make the best of the situation and try to improve it. Let not the reader misunderstand us to be advocating the policy of pure pacifism. The destructive tendencies of individuals and nations must be controlled, and controlled by force if necessary. The good Samaritan of the parable was commended; but would he not have been a better Samaritan if he had done his duty as a citizen and had taken up responsibilities which the priest and the Levite had shunned, and had seen to it that the road to Jericho was so policed and so protected that robbery would have been impossible on that highway? From the planetary point of view, the most thorough application of the principles of Christianity seems to be the only way to bring our planet up to the moral standard to be expected of it.

The principle of faith is not at all foreign to science and to its workers, and

this faith is quite akin to that of religion. The labor of scientists is chiefly directed by their faith in great principles, and by their firm belief that the universe is one of law. Otherwise why should men and women give up their lives in patient research in the endeavor to discover the principles which hold true and are part of the laws of nature? There would be no encouragement to such research if the operations of nature were purely capricious and without law. The process of scientific discovery is that of following some incomplete working hypothesis or theory based upon previous experiment or observation, and then of testing this hypothesis by further experiment and observation, holding to that part of it which proves to be good, and improving it as the work proceeds. Such faith in the eternal principles of the Creator, as we have said, differs not much from Christian faith in the eternal moral principles of God.

The idea of immortality of spirit is also not far different from some fundamental beliefs of the physicists. The name is different, and conservation of energy is the principle. This affirms that the

sum total of energy in the universe is constant, changeable from one form to another, but essentially immortal. Now this principle, to our thinking, cannot be rigorously demonstrated any more than can the immortality of spirit. Those who have crossed into the realm of spirit do not communicate with mortals; at least, there seems to be no thoroughly scientific evidence of such communication. The conservation of energy can be tested by experiment only within a limited field.

Another illustration is the theory of an all-pervading aether, a theory which has been tenaciously held by physicists for a century past. It is difficult, if not impossible, to demonstrate the objective reality of aether, but the mind demands the existence of a medium by which the waves of light may transfer their energy across the almost limitless void of space from distant suns or nebulae. Although the recent theory of Einstein, which postulates the aether in its initial stages as a theory, abandons it before it is through, it still remains to be seen whether or not a substitute for the aether has been found which

will be permanently acceptable to science.

We are contending for the view that the scientific study of the material world tends to separate the spiritual realm from that world—in other words, that it tends to make spiritual conceptions less material. In physics the fundamental notions or qualities which are not purely numerical are expressed in terms of mass, of length, and of time, that is, of quantity of matter, of extent in space, and of duration of time. These are technically known as "dimensions" of physical units. Thus, velocity is length divided by time; energy is mass multiplied by the square of length and divided by the square of time. By definition or common understanding of spirit, shall we not regard it as wholly divorced from mass or quantity of matter in the first of these dimensions? Secondly, can we associate length of extent with spirit? Does it not seem illogical, if not absurd, to think of a large spacial extent of spirit? Finally, may we not question whether spirit has any relation to time or the succession of material events? In other words, a spirit is wholly distinct

from matter; must it not also be beyond the restraint of the material "dimensions" of matter? If the possibility of this speculation is admitted, there would be no question *where* to answer in regard to spirit, and presumably no question *when*.

With the advancement of science, our recognition of the supremacy of law in the material world has greatly increased. The motions of the celestial bodies were among the first to be established by the immortal discoveries of Copernicus, Kepler, and Newton. Cause and effect are much more difficult to discover in biology, but the penetrating researches of Pasteur and many others have revealed the micro-organisms which cause diseases in men and animals. Many of the factors controlling men's actions and relations have been analyzed; much that was formerly attributed to a capricious deity has now been seen in a far more dignified light as the operation of natural law. Certain phenomena were long considered as beyond law, such as the lightning stroke and the tornado. These things were regarded as a divine retribution for human sin. Electric

discharges of a million volts are now produced in the laboratory and the weather conditions which develop tornadoes are gradually being understood so that they may be predicted with some degree of certainty. Human destiny is subject to these physical laws. Human lives are wiped out by storms, by floods, by disasters, but all as a consequence of laws as yet only partially understood. Science reveals critical stages in the changes of matter; for instance, water suddenly turns to steam as a certain definite temperature is reached. After a regular progress, an abrupt change may occur. In astronomy we have seen with our own eyes the sudden climax in the history of a star, when within thirty-six hours its light has increased many thousand fold, rising to be the rival of the brightest star in the heavens, and then fading away until it returns to its previous condition of relative inconsequence. Tycho saw such a star, as did Kepler, and two have attained the brilliance of the first magnitude within our own experience in the past quarter of a century. These cataclysms seemed at first purely fortui-

tous, sporadic, supernatural. But as minute study has been given to the changes in the spectra of these stars, we begin to see law and regularity in what was previously accident. In fact, it may be the destiny of any star to have its day of glory in the course of its evolution. Or such outbursts may occur periodically, repeating themselves after a few thousand years or longer. The record of science is still far too short to give a history of such cosmic phenomena. Thus, as science progresses, order and law become more and more recognizable, in the test tube or in the stars.

It seems to be a sacred and reverent duty to thoughtful men to go on with the study of these laws and to find man's relation to them. When they bear most heavily against him, he will seek to adapt himself to them, and he will always have as a supreme illustration these words of Christ, "Thy will, not mine, be done."

The quest of science is the Truth within the material universe; that of religion can be no less limited in its range, but refers more particularly to moral truths and the relation of man to the Creator and to his fellow-men. It is hard to see

why there should be an apparently deliberate effort to develop or to maintain an estrangement between these two forms of effort to gain useful knowledge.

We cannot be expected to believe that the inspiration of the seekers for truth has been confined only to those of certain limited periods, or of a certain race, or that the inspiration was ever complete, or that it ever has ceased to be given in some degree to honest workers in the quest for truth. For us, the two friends, Milton and Galileo, were glorious illustrations of inspired men of their time.

We have no worry about miracles. The marvels of life and growth that are daily seen about us in a natural way seem miraculous almost beyond belief, yet they are observed facts. Who can find the mathematical formulae under which that little bulb in my garden, subject only to the environment of soil, of water, and of air, can send up its shoots in April of each year, and develop in its exquisite detail the trumpet narcissus, always essentially the same and gathering up from its surroundings that delicate odor characteristic of it? Beside it may

grow the dandelion, subject to the same external conditions, but so different in the result.

Again, we are still very far from understanding how that frail, bright-hued bird can find his way across some hundreds of miles of sea and thousands of miles of land, back again to that maple tree where last year the nest was built. Yet, when at last such mysteries are solved after patient research, it will, of course, be found that they are operations of natural law in God's world. For Omniscience and Omnipotence there are no miracles. The development of a human being is doubtless as complicated as that of a star, but from the atom to the star and from the microbe to the man, we can believe that the same divine power holds sway.

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G. V. Douglas

from Cambridge 1933 Apr. 8

40 years of Astronomy

by

Sir A. S. Eddington

Circa 1930.

VI. FORTY YEARS OF ASTRONOMY

by

SIR ARTHUR EDDINGTON
Plumian Professor of Astronomy,
Cambridge

ASTRONOMY

If we compare astronomy to-day with astronomy forty years ago, we notice a centrifugal tendency. Astronomical books in the 'nineties generally gave a full account of the sun, moon, planets, and comets, but could find little to tell us about the fixed stars. The centre of interest has now shifted from the solar system to the system of the stars, and beyond. We are likely to-day to hear more about galaxies than about planets.

This contrast may give a misleading idea of the pursuits of astronomy forty years ago. Actually the systematic observation of the stars was then absorbing the main energy of observatories, as it had been doing throughout the eighteenth and nineteenth centuries. In some of the work the stars were observed, not as celestial objects interesting in themselves, but as auxiliary to other researches; they were the reference marks, or graduations on the dial of the heavens, whose positions must be precisely calibrated to serve for measuring the movements of planets and comets. But besides routine observation of position, there were many kinds of investigation more directly concerned with the nature of the stars themselves. In 1900 the position was that, although actual results were still scanty and uncertain, the labours of many decades were approaching fruition and a rapid advance was in prospect.[1]

[1] An authoritative account of our knowledge at this time will be found in Newcomb, *The Stars. A Study of the Universe* (John Murray, 1902).

For an understanding of the system of the stars the first essential is a general knowledge of stellar distances. The distances of two of the nearest stars, α Centauri and 61 Cygni, were determined in 1839; but there had not been very much advance in our knowledge by 1900. The number of well-determined parallaxes had increased to about 20; but these were not discriminated from a large number of inferior and quite misleading determinations. Even in 1910 the generally accepted catalogue of parallaxes listed 88 stars within 10 parsecs distance of the sun, of which 40 have since been rejected as beyond the limit. We knew very little about the distances of individual stars, and—much worse—we did not know how little we knew.

Soon after 1900 a great improvement was made by determining stellar parallaxes photographically instead of with a heliometer. The pioneers of the photographic method were Schlesinger at the Allegheny Observatory and Russell and Hinks at Cambridge. When the distance of a star has been found by parallax determination, its apparent brightness can be converted into absolute (intrinsic) brightness. The number of well-determined parallaxes now available is sufficient to give a good idea of the range of absolute brightness of the stars, and of the dependence of brightness on spectral type and other characteristics. The direct method of determining distances is of very limited application, since most of the stars are much too remote to give measurable parallax. But from knowledge of the nearer stars (within, say, a hundred light-years of

the sun) derived in this way we have obtained a firm basis for developing and controlling a number of indirect methods of estimating the distance and absolute brightness of more remote stars—so that, by a series of steps, distances of objects up to 300 million light-years are now ascertainable.

Another type of measurement which developed very slowly was the determination of the radial velocities of stars. In principle the rate of approach or recession of a luminous body in the line of sight can be found by measuring the Doppler shift of its spectral lines. This was first applied to the stars by Huggins in 1868; but by 1900 we still did not know the radial velocity of any star. If any good determinations then existed, they were buried among the totally erroneous determinations. The practical development of the technique of this measurement is due to Campbell at the Lick Observatory. In 1913 trustworthy radial velocities of 1400 stars were available.

One kind of datum was fairly abundant in 1900, namely proper motion, i.e. the apparent angular motion of a star across the sky. These motions are larger than is often supposed; and with modern appliances it is the exception for a star to show no detectable motion in twenty years. The fastest motion is that of a faint star of magnitude 9·7 known as Munich 15040 (or less officially as Gilpin) which covers 10·3 seconds of arc per year; it would be just possible to detect its motion between two consecutive nights. Our knowledge of proper motions up to 1900 rested mainly on Bradley's

observations of the positions of some 3000 bright stars around 1755, which were compared with the modern positions. Whenever a new catalogue of proper motions was produced, it seemed to be taken for granted that the one use for it was to determine the Solar Apex, i.e. the direction of the sun's motion relative to the system of the stars. You might think that this occupation would pall after a time; but happily each new determination disagreed with the older ones, and thus gave astronomers plenty to talk about.

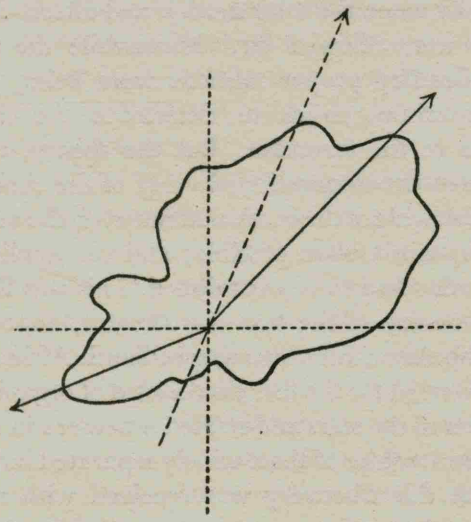
In a general way the effect of the sun's motion amid the stars is quite conspicuous. If we plot the proper motions of stars in a small region of the sky we notice at once a preponderance in one direction; the stars in the mean are moving in that direction relatively to the sun. This is expressed equivalently (but more modestly) by saying that the sun is moving in the opposite direction relatively to the stars. But though the general effect is plainly seen, an exact determination of the direction is difficult, since the apex is sensitive to small systematic errors in the system of the proper motions which we are still endeavouring to eliminate.

Just at the time I entered astronomy (at Greenwich in 1906) a revolutionary discovery had been made. The greatest pioneer in the study of stellar statistics was Prof. J. C. Kapteyn of Groningen. There is now a long series of "Groningen Publications" relating to these problems. The most interesting of them all is No. 6. But it is no use going to a library to consult it; for the interesting thing about No. 6 is that it was never written. Nature

took an unexpected turn, and would not fit into the scheme which No. 6 was promised to elaborate. No. 5 was entitled "The distribution of cosmic velocities: Part I, Theory"; it was a study of how the motions of stars pursuing their courses at random would turn out statistically when the solar motion and effects of varying distance were allowed for. Meanwhile the observed Auwers-Bradley proper motions were being prepared for comparison, so as to determine the numerical constants in the formulae. But the theory, though it represented the unquestioned views of the time, turned out to be so wide of the mark that not even the beginnings of a comparison were possible; and the application of the formulae had to be abandoned. This was Kapteyn's great discovery of the two star streams, announced at the British Association meeting in South Africa in 1905, which revealed for the first time a kind of organization in the system of the stars and started a new era in the study of the relationships of these widely separated individuals.

At first this discovery was received with much incredulity; but to any one who took the trouble to examine the proper motions for himself there could never be any doubt. For example, the diagram overleaf shows the statistics of distribution of the proper motions in a typical region of the sky; the radius from the origin to the curve in any direction is proportional to the number of stars whose motions are in that direction. You can see easily that there are *two* favoured directions of motion, indicated by the full arrows. The direction towards the solar antapex is shown by the broken arrow; although

the stars in the mean move in this direction, they do not favour it individually. Evidently the double streaming cannot be accounted for by the parallactic effect of the sun's own motion; it is an intrinsic peculiarity in the distribution.



The phenomenon of two star streams has been abundantly confirmed; and it is found to prevail everywhere in the region over which our surveys of proper motions extend. Its real significance is still uncertain. It may be that in our neighbourhood two large clusters of stars have met by accident and are passing through one another. But in modern discussions star-streaming has to be considered in conjunction with another effect whose existence was demonstrated by Oort of Leyden

about 1927. The whole galaxy is found to be rotating about a centre which lies 10,000 parsecs away in the direction of the constellation Sagittarius. This centre is fairly near to the vertex of the preferential motion; though according to the best determinations there is a difference of about 10°, which seems to be real. It suggests itself that Kapteyn's phenomenon is primarily a tendency for the stars to move radially (towards or away from the centre of the galaxy) rather than transversely, and that it is a general feature of the dynamics of the system.

In accordance with the law of gravitation it is necessary that the rate of revolution of the galaxy should decrease outwards; just as in the solar system the outer planets revolve more slowly than the inner planets. Our survey of proper motions and radial velocities extends over what is after all only a small part of the whole galaxy; consequently in actual observation we are concerned only with the *differential* rotation in this small region. Since the outer part of a region travels more slowly than the part nearest the galactic centre, the region must become distorted. Considering a square with ourselves at the centre, the square will become sheered into a diamond. The stars seen in the two opposite directions corresponding to the lengthening diagonal will therefore (on the average) be moving away from us; those 90° away, corresponding to the contracting diagonal, will be coming towards us. The sheering effect, by which motions of approach and motions of recession follow at intervals of 90° of galactic

longitude—or, as it is briefly described, the double-period term in the average radial velocity—is shown by all classes of distant stars. The results of the analysis, giving the direction of the centre and the magnitude of the differential rotation, are very accordant. The rotation indeed provides a means of estimating the average distances of various classes of stars; since the amplitude of the double-period term, which we obtain by analysis of the observed radial velocities, is proportional to the distance. This illustrates one of the indirect methods by which our knowledge of celestial distances has been extended beyond the limits within which parallax measurement is possible.

We are a long way from the centre of the stellar system—perhaps about half-way out towards its confines. In our neighbourhood the orbital speed is about 250 kilometres per second, and the time required for a complete revolution is of the order 250 million years. It is interesting to reflect that we have made five or six complete revolutions round the system within geological times. It is also possible to infer the mass of the system, which controls this orbital motion. It must be about 150,000,000,000 times that of the sun; so that presumably the system contains something like that number of stars. This is about ten times the number estimated by extrapolation of actual counts of stars; but it is not incredible, because vast numbers of stars may be hidden by the clouds of obscuring matter which are observed in various parts of the system and especially in directions towards its centre.

To return to the state of our knowledge in 1900—it was realized that the stars form a limited system strongly flattened in the galactic plane like a bun or lens. Newcomb, who was one of the leading authorities, concluded that the boundary of the stellar universe was nowhere distant more than 3000 light-years and might possibly be much less. The diameter now assigned to it is at least 20 times greater. But that is by no means the whole magnification that our conception has undergone. This huge system of a hundred thousand million stars is only the beginning; it is one island galaxy among many. Out beyond it there are other islands, recognized by us as spiral nebulae. From sample counts it is computed that 10,000,000 of these galaxies, coequal with our own island system, are detectable with our present telescopes; and doubtless there are far more outside their range. In forty years the "boundary" of the material universe has been pushed back from 3000 light-years to beyond 500,000,000 light-years, which is the present limit of telescopic survey.

The status assigned to the spiral nebulae has undergone remarkable vicissitudes. The hypothesis that the nebulae are island galaxies was first put forward by Sir William Herschel, and for a time was widely accepted. When the spectroscope was introduced, Huggins found that many of the most conspicuous nebulae show the bright-line spectrum of a gas and are clearly not galaxies of stars. This discredited the island theory; and all the nebulae were brought inside our galactic system again. Later it became clear that the spiral or

"white" nebulae are a different class of objects from the nebulae with gaseous spectrum. About 1910 the island theory was revived as regards the spiral nebulae. It was advocated especially by Sir David Gill and an international group of astronomers associated with him; but Van Maanen, Jeans and others took the opposite view, and the question was strongly contested until 1924, when Hubble produced conclusive evidence that the spiral nebulae are extragalactic. The gaseous nebulae on the other hand are intragalactic.

In some of the nearer spiral nebulae it is possible to recognize individual stars. Hubble found among them some Cepheid variables, and determined the periods of their light-variation. It is known from the study of Cepheid variables in our own galactic system that the period is a trustworthy indicator of the intrinsic brightness. Thus the absolute light-power of these stars could be assigned; and, by comparing it with their apparent brightness, the distances of the Cepheids, and of the nebulae containing them, were deduced. These distances showed them to be far outside our own galaxy.

The spiral nebulae are found to be moving away from us systematically with speeds approximately proportional to their distances. This indicates that the whole system of the galaxies is dispersing. At the present rate of expansion its dimensions will become doubled in 1500 million years—a period comparable with the age of the earth's crust. The rapidity of this change of the large-scale structure of the universe has profoundly modified our ideas of the time-scale of evolution in

astronomy. Upper limits to the ages of the stars had been calculated on the extreme assumption that the whole of the energy of constitution of the matter contained in them is available for radiation; for example, the upper limit for the sun is five billion ($5 . 10^{12}$) years. Formerly it was widely believed that the actual ages correspond to these upper limits; but such values are now altogether incongruous. We cannot well assign to the stars a past duration more than a small multiple of the "time of relaxation" of the system of galaxies. For this and other reasons the age is now put not higher than 10^{10} years.

I dare not enter further into the discussion of this expansion of the universe, lest I be tempted to spend the rest of the lecture over it. But in view of the false impressions which exist, it is desirable to emphasize that it is a straightforward development of astrophysical research in which observation and theory very happily agree. The cause of the expansion is a force known as "cosmical repulsion" which is foretold by the equations of relativity theory. At very great distances Newtonian attraction is modified by this supplementary force, and in the system of the galaxies the resultant effect is a repulsion which scatters the galaxies apart. It would be contrary to the scientific spirit to represent this, or any other result described in this lecture, as safe from revision through the progress of knowledge. But it is not one of the more precarious advances; and there is no excuse for those who treat cosmogony as a field for unguided speculation of a type which would not be tolerated in any other

branch of physical science. I think that a joint paper by Einstein and de Sitter a few years ago must be held partly responsible for this wave of speculation. It was a piece of mathematics, innocuous in itself, but put in such a way as to give the impression that these distinguished authorities had become sceptical about the cosmical constant. Einstein came to stay with me shortly afterwards, and I took him to task about it. He replied: "I did not think the paper very important myself, but de Sitter was keen on it." Just after Einstein had gone, de Sitter wrote to me announcing a visit. He added: "You will have seen the paper by Einstein and myself. I do not myself consider the result of much importance, but Einstein seemed to think that it was."

To return to historical order, after the discovery of the star streams the next big sensation in stellar astronomy was the Giant and Dwarf theory put forward by Hertzsprung and Russell, which came into prominence about 1913. In 1900 we were supposed to understand thoroughly the course of stellar evolution—the stars passed through the sequence of spectral types B, A, F, G, K, M in order, ending up as dark stars. The description of spectral types as "early" or "late", which is still commonly used by force of habit, is a reminder that at one time the above sequence was accepted with the utmost confidence. But whereas in most branches our knowledge has greatly advanced, our knowledge of stellar evolution seems to have diminished, until now it is represented approximately by the symbol o.

Apart from any evolutionary interpretation, the order

B, A, F, G, K, M is that of diminishing temperature; the supposed passage of a star down this sequence therefore signified that its surface continually cooled. Hertzsprung and Russell discovered that each of the "later" types comprises two distinct classes of stars, widely different in absolute brightness and presumably also in physical condition. Within any one spectral type the surface luminosity must be approximately the same; thus the difference of brightness can only be attributed to difference of size. For example, the M stars are divided into a group of huge diffuse "giants" and a group of small concentrated "dwarfs"—with no intermediate M stars. As we go up the spectral sequence the giant and dwarf groups converge, and they coalesce in types A and B. To put the stars in order of increasing density, we must begin with the M giants, go up the sequence M, K, G, F along the giant branch to A or B, and then come down the dwarf branch to M again. Hertzsprung and Russell took this to be the order of evolution, the stars being supposed to begin as condensations in nebulae and to contract continually as they radiated away their heat.

It had been shown by Homer Lane in 1870 that when a gaseous star contracts its internal temperature must rise; this seemed to account for the ascending part of the evolutionary sequence which corresponds to diffuse giant stars. At the turning point in type B or A the density is beginning to approach that of water. It was naturally thought that the gas theory then ceased to apply; the second half of the evolutionary sequence

accordingly followed, in which the star descended the dwarf branch cooling like a liquid or solid mass. We notice that the keystone of the Hertzsprung-Russell theory of evolution was that the change over from ascending to descending temperature occurs when the star becomes too concentrated to behave as a perfect gas. In view of the subsequent collapse of this theory we may call attention to a weak point in the argument. It confused the *internal* temperature (treated in Lane's theory) with the *surface* temperature (indicated by the spectral type); these do not necessarily increase and decrease together.

The distinction of giants and dwarfs was a very important advance. In modern classification there is a slight modification. We recognize three groups: firstly, the Main Series, which is the old dwarf branch prolonged to include types A and B and a still hotter type O; secondly, the Giants, which are not very numerous in space, but owing to their great brilliance furnish the majority of the naked-eye stars; thirdly, the White Dwarfs, which fall on the other side of the main series, and have transcendently high density. But the evolutionary part of the theory has been abandoned altogether. It was my lot to bring about its fall in 1924 by showing that the dwarf stars, notwithstanding that their density is as high as that of terrestrial liquids and solids, are still in the condition of a perfect gas and have the compressibility of a gas. That contradicts what I have called above the keystone of the theory. Another upsetting result was that the absolute brightness of stars (other than

white dwarfs) is determined almost wholly by their masses and is little affected by their density; in particular, a dwarf has much smaller mass than a giant of the same type, so that we cannot take them as representing later and earlier stages of the same star—unless indeed a star loses mass as it grows older. For a time it seemed possible to save the Hertzsprung-Russell sequence of evolution by postulating that a star during its lifetime radiates away a large proportion of its mass. But this suggestion, which involves the hypothesis that electrons and protons can annihilate one another, has been undermined by the recent discoveries in atomic physics; and, moreover, the shortened time-scale already mentioned gives insufficient time for the required decrease of mass by radiation.

Certain distinctive characteristics in the spectra of giant and dwarf stars have been found, so that they can now be distinguished easily without examining their absolute brightness. By an elaboration of the same principle Adams and Kohlschütter developed in 1914–16 a spectroscopic method of determining absolute brightness. As already stated the stars can be arranged in sequence in order of surface temperature, certain features of their spectra being used as criteria. Other less obvious features give a classification which runs athwart the temperature classification. It is found that this transverse classification is governed by the absolute brightness. This gives an empirical method of determining the absolute brightness, stars whose absolute brightness is already known being used to calibrate the

scale. By comparison with the apparent brightness we can deduce the distance or parallax. The results of this method are therefore called "spectroscopic parallaxes".

In 1920 the angular diameter of a star was measured for the first time by Pease and Anderson with an interferometer constructed by Michelson. The stars are so distant that no disc can be seen even in the largest telescope; the image is always indistinguishable from that of a point. Actually it is not difficult to compute their angular diameters from their apparent brightness and the approximately known effective temperatures of the different spectral types; but a check on the theory is always desirable, particularly as in this case it led to what appeared to be outrageously improbable results for the companion of Sirius and other white dwarfs. Probably no star has a disc greater than $\frac{1}{20}$th of a second of arc; the largest should be those of the first magnitude stars of type M, namely Betelgeuse and Antares. Using apertures separable up to 20 feet, after the pattern of a range-finder, Pease and Anderson obtained diffraction effects for Betelgeuse from which a diameter of 0″·045 was deduced. This gives a linear diameter of about 300 million miles; that is to say, Betelgeuse is large enough to contain the orbit of Mars. To extend the method to somewhat smaller stars a 50-foot interferometer was built; but it was not brought into successful use until 1936.

I became interested in the theory of the interior of a star in 1915. The hypothesis that the variable stars of a particular class known as Cepheids are pulsating stars,

first proposed by Plummer, had recently received strong support from the researches of Shapley; and I wanted to investigate the thermodynamic problems connected with the maintenance of a pulsation. But it was not until some years later that I was in a position to begin the investigation of pulsations; for it soon became clear that the existing theory of a static star needed to be modernized to correspond with advances which had been made in the physics of radiation.

You must understand that by "modernized" I do not mean that I intended anything so revolutionary as the introduction of quantum theory. I suppose I believed in quantum theory after a fashion—in so far as anyone could believe the tissue of inconsistencies that it then was. But it was not the sort of thing for a matter-of-fact astronomer to have dealings with. You may find it difficult to recall the outlook of those benighted days. Let us go back to 1912. At that time quantum theory was a German invention which had scarcely penetrated to England at all. There were rumours that Jeans had gone to a Conference on the continent and been converted; Lindemann, I believe, was expert on it; I cannot think of anyone else. Soon afterwards Bohr's theory of the atom appeared, and quantum theory reached the stage at which one says: "There seems to be something in it, and I really must read it up when I get time." By 1915 everyone was reading Jeans' "Report on Quantum Theory", published by the Physical Society; and upholders of the "pint-pot" type of explanation were being driven into the last ditch.

So the theory was very much under discussion. But as you must have realized, I am always very conservative in my outlook and do not accept anything until it has become quite obvious that it is true; and I did not want the work I was doing on the structure of the stars to be mixed up with half-baked theories.

However, a point soon arose where quantum theory could not be evaded. Following all earlier writers I had taken the ultimate independent particles in stellar material to be atoms, and had adopted appropriate masses for them. Newall first suggested to me that it was more likely that there would be complete ionization, setting free all the satellite electrons; if so the average mass per particle would be much lower. The quantum experts Jeans and Lindemann were of the same opinion. It seems to have been a matter of opinion only, for there was no recognized quantum theory of ionization at that time. I found the suggestion attractive, because it made my numerical results nearly independent of the unknown chemical composition of the stars, the average molecular weight of fully ionized matter being nearly the same for all elements except hydrogen. Calculations were therefore made both on the assumption of high ionization and of low ionization, it being left to observational comparison, or to the future development of theory, to decide between them.

The present ionization formula, as given by quantum theory, was first applied to the stars by Eggert in 1919; and it confirmed the hypothesis of high ionization which was already provisionally assumed. In 1921 Saha studied

in the same way the state of ionization of the outer layers of a star, and started the modern theory of the interpretation of stellar spectra. This has opened out a very wide field of practical and theoretical investigation. It is in fact the parent of most of the problems of modern astrophysics.

One outcome of the theory of the interior of a star was the realization that matter in dwarf stars, though comparable in density with iron or water, still behaves as a perfect gas and is therefore far from the limit of compressibility. There is no obstacle to densities hundreds or thousands of times greater. It suggested itself that this was the explanation of a difficulty presented by the white dwarf stars. The companion of Sirius, for example, gives only $\frac{1}{360}$th of the light of the sun, although judging by the spectral type its surface should radiate more strongly. The star must therefore be much smaller than the sun, the computed diameter being no more than 25,000 miles. The resulting density, about 60,000 times the density of water, had appeared to indicate a fallacy in the deduction, and had cast suspicion on the reliability of spectral type as a guide to temperature. But on the new theory the high density was not incredible, and the calculation might be accepted literally.

To decide the question Adams investigated the Einstein shift of the spectral lines in the companion of Sirius. The shift, which is proportional to the gravitational potential at the surface of the star and therefore varies as mass divided by radius, would be very large if the small radius were correct. In 1925 the large shift was

observed, and the high density was confirmed. Even this is not the highest stellar density; although only rough estimates can be given for the other known white dwarfs, it appears that in some of them the density must be at least 100 tons to the cubic inch.

Up to 1924 no one seems to have given serious thought to the possibility of superdense matter. By a strange coincidence, just when astronomers were discovering its existence in the white dwarf stars, the thoughts of pure physicists were independently turned in the same direction. Wave-mechanics was found to introduce deviations from the classical statistical theory of particles, which in general could only be appreciable at extremely high density. To those seeking an application of the new theories the white dwarfs were a godsend. The new (Fermi-Dirac) statistics were first applied to them by R. H. Fowler, who thereby cleared up a serious difficulty as to the energy-content of the white dwarfs.

In the later part of the period here surveyed the greatest advance perhaps has been in the study of gaseous nebulae. These are extremely rarefied objects with density generally of the order 10^{-20} gm. per cu. cm. Some of them (planetary nebulae) surround one star only; others (irregular nebulae) are much more extensive and enclose many stars. In all cases one or more stars of very high temperature must be enclosed, because the nebular light is due to stimulation by extreme ultra-violet radiation from the stars. The light is not a simple reflection but a fluorescence effect.

For many years the principal puzzle was the nature

of the bright spectral lines responsible for the light of the nebulae, since the most conspicuous lines could not be traced to any known element. A new era began in 1927 when Bowen found that a number of the unknown lines were "forbidden" lines of ionized oxygen and nitrogen. In fact the material which had puzzled us was just air. These forbidden lines have not been observed in the laboratory; but their theoretical wave-lengths can be calculated from those of the ordinary lines in the spectrum of the same element and identified with the observed nebular wave-lengths. They represent downward transitions from a metastable state, that is to say a state in which the atom will usually remain a long time (from a second to several hours) before it falls to a lower state with emission of radiation. Consequently to emit forbidden lines the atom needs to be left undisturbed for long periods—a condition impossible to secure in the laboratory but satisfied in the nebulae, where the sparsely strewn atoms and electrons travel for hours without colliding, and the radiation is so dilute that encounters with photons are equally rare.

Following up this result Zanstra produced a very fascinating theory which traces in detail the transformations of radiation in the nebula, enables the effective temperature of the stimulating star to be calculated, and accounts for the principal facts observed. Unfortunately it is too lengthy and technical to be described here.

I need scarcely say that in this brief survey of forty years' progress in astronomy much must be omitted; I must not, however, neglect the solar system entirely.

Its recognized membership has increased by four more satellites of Jupiter, one of Saturn (discovered in 1898), 940 minor planets (bringing the total to 1380), and one major planet Pluto. The trans-Neptunian planet Pluto was discovered by Tombaugh in 1930. It has a period of 248 years as compared with Neptune's 165 years, and a mean distance from the sun 3600 million miles compared with Neptune's 2800 million miles; but its orbit is so eccentric that at perihelion it comes slightly nearer to the sun than Neptune. Estimates of its diameter and mass are still only hypothetical; but it seems certainly smaller than the earth, and may perhaps be about the size of Mercury. It was found in the course of a search made at the Lowell Observatory for a trans-Neptunian planet predicted by the late Prof. Lowell from a study of the perturbations of Uranus. It turned up close to the predicted spot. But it has since been shown that it could not have been responsible for the perturbations, and the agreement must be set down as pure coincidence.

Perhaps the most generally interesting advance in this part of astronomy has been the spectroscopic study of the atmospheres of planets. Our familiar atmosphere of oxygen and nitrogen, with a certain amount of water-vapour, is not by any means a standard equipment. The atmosphere of Mars, though rather scanty, is not dissimilar to that of the earth; but all the other planets show significant differences. Mercury (like the moon) shows no trace of an atmosphere. Venus is covered by thick cloud and only the upper atmosphere above the cloud can be examined; its spectrum shows carbon

dioxide, but no oxygen. It is thought that this signifies that there is no vegetation of the terrestrial type on Venus; since on the earth vegetation performs the function of absorbing carbon dioxide from the atmosphere and returning the oxygen. This is in keeping with another line of speculation which had suggested that the surface of Venus is entirely covered by ocean. On Jupiter and Saturn we find atmospheres of an entirely different constitution, namely a mixture of methane and ammonia—which seems an extraordinarily unpleasant combination! The proportion of ammonia is less on Saturn than on Jupiter; and on the still more remote planets Uranus and Neptune only methane has been detected. This progressive decrease of ammonia may be attributed to the increasing cold which removes it from the atmosphere by liquefaction.

The presence of hydrides (CH_4 and NH_3) in the atmospheres of the four large planets suggests an excess of hydrogen in their composition. In the last ten years we have come to realize that hydrogen is an extremely abundant element. Studies of the interior of a star, of the surface layers of stars, and of the gaseous nebulae, have all independently led to this conclusion; and one of the leading factors in the progress of the last ten years has been the revision of older views which had not appreciated the important part played by this element. It can generally be taken that hydrogen is nearly as abundant by mass as all the other elements put together, and far more abundant if we reckon by number of atoms. We therefore assume that when the planets were formed

from the sun, the material originally contained abundant hydrogen. That it is not so important a constituent of the earth is explained by the theory of escape; the earth's gravitational field was not strong enough to prevent the light and fast-moving atoms of hydrogen from leaking away. But the massive outer planets have a stronger field and could retain their hydrogen. This gives a satisfactory explanation of the different constitution of their atmospheres; and a detailed chemical study of the problems raised throws much light on the physical condition of these planets. I will only add here that the conditions are intensely cold, and all the water must lie ice-bound on the planet's surface—concealed from us and from the sun's rays by the deep opaque atmosphere.

I will devote the few minutes which remain to the most exciting event I recall in my own connection with astronomy, namely the verification of Einstein's prediction of the deflection of light at the eclipse of 1919. The circumstances were unusual. Plans were begun in 1918 during the war, and it was doubtful until the eleventh hour whether there would be any possibility of the expeditions starting. But it was very important not to miss the 1919 eclipse, because it was in an exceptionally good star-field; none of the subsequent expeditions have had this advantage. Two expeditions were organized at Greenwich by Sir Frank Dyson, the late Astronomer Royal, the one going to Sobral in Brazil and the other to the isle of Principe in West Africa. It was impossible to get any work done by

instrument-makers until after the armistice; and, as the expeditions had to sail in February, there was a tremendous rush of preparation. The Brazil party had perfect weather for the eclipse; through incidental circumstances, their observations could not be reduced until some months later, but in the end they provided the most conclusive confirmation. I was at Principe. There the eclipse day came with rain and cloud-covered sky, which almost took away all hope. Near totality the sun began to show dimly; and we carried through the programme, hoping that the conditions might not be so bad as they seemed. The cloud must have thinned before the end of totality, because amid many failures we obtained two plates showing the desired star-images. These were compared with plates already taken of the same star-field at a time when the sun was elsewhere, so that the difference indicated the apparent displacement of the stars due to the bending of the light-rays in passing near the sun.

As the problem then presented itself to us, there were three possibilities. There might be no deflection at all; that is to say, light might not be subject to gravitation. There might be a "half-deflection", signifying that light was subject to gravitation, as Newton had suggested, and obeyed the simple Newtonian law. Or there might be a "full deflection", confirming Einstein's instead of Newton's law. I remember Dyson explaining all this to my companion Cottingham, who gathered the main idea that the bigger the result, the more exciting it would be. "What will it mean if we get double the

deflection?" "Then", said Dyson, "Eddington will go mad, and you will have to come home alone."

Arrangements had been made to measure the plates on the spot, not entirely from impatience, but as a precaution against mishap on the way home; so one of the successful plates was examined immediately. The quantity to be looked for was large as astronomical measures go, so that one plate would virtually decide the question, though, of course, confirmation from others would be sought. Three days after the eclipse, as the last lines of the calculation were reached, I knew that Einstein's theory had stood the test and the new outlook of scientific thought must prevail. Cottingham did not have to go home alone.

I have told you, as best I can, something of what we have learnt in the last forty years. I will end by expressing a hope—not unmingled with doubt—that not too much of what I have been saying will be upset in the next forty years.

Telephone:
10 Shere

The Spinning Walk,
Shere,
Guildford.
Surrey.

21/8/30 19

Mrs Dayton

To Dr. G. E. Davidson

For Professional Attendance, &c.

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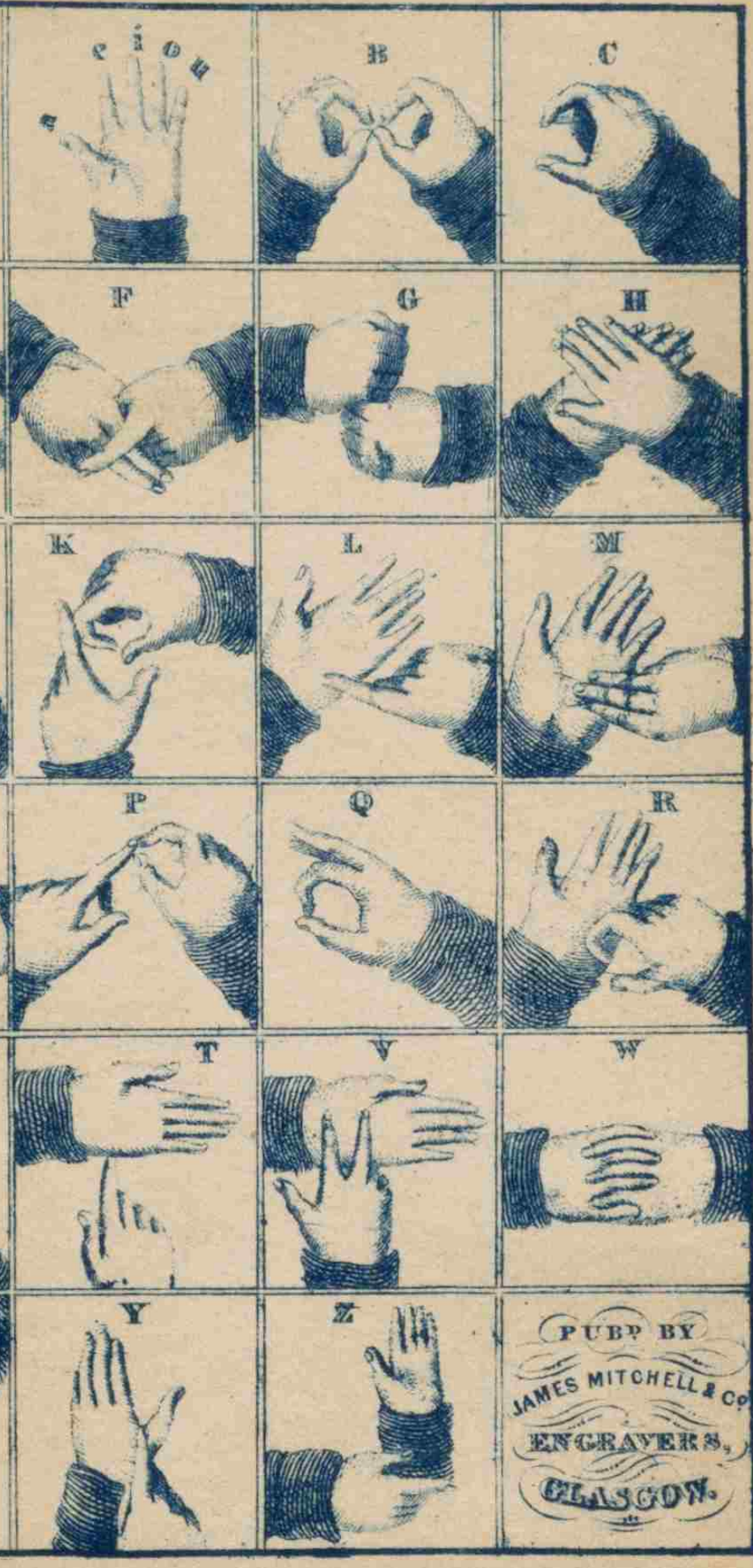

PUBP BY
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Mr. & Mrs. Frank D. Adams.

1st & 3rd Fridays.

Will you accept
this little spoon
which I brought for
from Florence as
a token of much
love?, and may it
often stir the "cup
that cheers".
My thoughts have been
much with you all
these past days.
May the New Year be
one full of blessings
to you all dear -

SOCIAL and PERSONAL

Dr. and Mrs. F. D. Adams are leaving tonight for Washington, D.C., to attend the meeting of the National Academy of Science, and will be away until the end of next week. Early in May they will go to Victoria, B.C., for the Pacific Scientific Congress meeting.

Mr. H. H. Ferguson, Sherbrooke street west, sailed yesterday, by the Montclare, to spend a few weeks in England.

Mrs. Walter Davis, of Ottawa, is spending the week-end at Knowlton with her cousin, Mrs. A. F. Baillie.

The Hon. Vincent Massey and Mrs. Massey, who were at the Ritz-Carlton Hotel this week, have returned to Port Hope.

Miss Jones, of Portland, Maine, is visiting Mrs. Anson McKim.

Mr. and Mrs. Elmo Ashton, of Brampton, Ont., are at the Windsor Hotel.

The Canadian Women's Press Club, Montreal branch, is holding a luncheon today at one o'clock, at the Ritz-Carlton Hotel, when Mr. Hector W. Charlesworth, chairman of the Canadian Radio Commission, Ottawa, will be the guest of honor and speaker.

The Alumnae Society of McGill University is holding a tea-dance this afternoon, at half-past four o'clock, in Convocation Hall, Royal Victoria College.

Mrs. Louis Beaubien sailed yesterday by the Alaunia, to join her mother, Mrs. J. R. Douglas, in France. They will return early in June.

Mr. and Mrs. A. D. McDonald, of London, England, are at the Windsor Hotel.

Miss E. Williams-Moore is motoring to Boston today with her sister, Mrs. Charles M. Tucker, and Mr. Tucker, who have been visiting in Montreal for a few days.

Mrs. H. C. Hammond, who motored to Atlantic City for Easter, is now in New York at the Waldolf-Astoria for a few days. She is accompanied by Mr. and Mrs. M. S. Bogert.

The Ladies Branch of the Hampstead Golf Club will hold a general meeting at the Mount Royal Hotel, Salon B., on Tuesday afternoon, at three o'clock.

Major C. A. Harrison and Mrs. Harrison sailed from Boston yesterday, by the Lady Rodney, for the West Indies.

Mr. George Hutchings, of Burlington, Ont., sailed yesterday by the Alaunia for England, to be away until the middle of June.

Mrs. Frank L. Packard, St. Joseph street, Lachine, is entertaining at the tea hour this afternoon in honor of Miss Enid Watts, whose marriage to Mr. George Binks takes place in Toronto, on Saturday afternoon next.

The engagement is announced of Jeannine, daughter of Mr. and Mrs. J. Alex. Prud'homme, of Westmount, and grand-daughter of the late Judge H. C. Saint-Pierre, to Mr. Gerald K. Cushing, son of Mr. and Mrs. Lemuel L. Cushing, of Westmount.

Mr. and Mrs. K. S. Barnes are expected home this week-end from New York, where they have been at the Barclay Hotel. Mrs. Barnes having gone to New York to meet Mr. Barnes on his return from Europe.

Mr. and Mrs. George R. Atchison returned yesterday from New York, where they spent a few days at the New Weston Hotel, en route from Virgina Beach, Va.

Mrs. H. E. Stephenson, of Montreal West, is entertaining at an "at home" this afternoon for Miss Freda Wilkinson, whose marriage to Mr. Harold E. Stephenson is taking place on May 6. The tea table, centred with spring flowers, will be presided over by Mrs. G. E. Wilkinson, Mrs. G. Fred. Hughes, Mrs. Josh. Peters and Mrs. Harry L. Cook, assisted in serving by the Misses Kathleen Fowler, Dorothy Forrester, Marjory Cook, Doris Hughes and Muriel Sowerby.

Mr. and Mrs. Alexander Rae, of San Juan, Porto Rico, announce the engagement of their daughter, Cicely, to Mr. Arthur Graham Tyner, youngest son of the late Mr. and Mrs. Henry Tyner, of Dublin, Ireland. The marriage will take place quietly at the end of May.

The engagement is announced of Margaret Geraldine, eldest daughter of Mr. James P. O'Loghlin, of Toronto, to Mr. Walter Albert Stanford, son of the late Joseph S. Stanford and Mrs. Stanford, of Westmount. The wedding will take place quietly in June.

A dinner for the members of the University Club will be held at the club house, 3492 Peel street, on Wednesday evening, April 26.

Mr. and Mrs. Jean Simard, of St. Jerome, announce the engagement of their daughter, Pierrette, to Mr. George Ouellette, son of Mr. and Mrs. U. Ouellette, of Montreal.

OTTAWA SOCIAL NOTES

(Special to The Gazette.)

Ottawa, April 21. — Her Excellency the Countess of Bessborough, accompanied by Lady Moyra Ponsonby, sailed today on the Duchess of Bedford for Canada.

Mr. Ralph Alderson, of London, England, will arrive in Ottawa tomorrow and will stay at Government House during the Dominion Drama Festival.

Sir William and Lady Clark will spend the week-end in Toronto.

Miss Betty Campbell, of Hamilton, will be the guest of Mrs. H. S. Southam during the Dominion Drama Festival.

Sir Percy and Lady Sherwood are returning on Sunday from Atlantic City.

Miss Dorothy Somerset, of Vancouver, who will be in Ottawa next week for the Dominion Drama Festival, will be the guest of Mrs. Mark Vernon.

Captain and Mrs. Roy Angus have returned to Montreal.

Miss Ruth White, of London, Ont., will be the guest of Mrs. Gordon Gunn, for the Dominion Drama Festival.

Miss Margaret and Miss Mary Laidlaw are sailing for England next wek.

Mrs. Arthur Craig, of Toronto, is the guest of her brother and sister-in-law, Mr. and Mrs. F. C. J. O'Hara.

Mr. and Mrs. Graham Mayburry have returned from Toronto.

The Misses Gladys and Joan Carling entertained at a dance this evening.

Mr. Cyril Hessey White, of Montreal, will be the guest of Mr. and Mrs. W. R. Creighton during the Dominion Drama Festival.

Miss Molly Broughall, of Hamilton, will be the guest of Mrs. Montague Powell during the Dominion Drama Festival.

QUEBEC SOCIAL NOTES

(Special to The Gazette.)

Quebec, April 21.—Mrs. Stuart Ritchie and her daughter, Miss Edith Ritchie, who spent the winter in Montreal, are arriving in Quebec tomorrow and will spend a few days before going to Lake Edward. Mrs. Ritchie will visit her mother, Mrs. G. B. S. Young, while Miss Ritchie will be the guest of her uncle and aunt, Mr. and Mrs. Edward Staveley.

Mrs. W. C. Hodgson, Mrs. Alex McDougall, Mrs. A. T. Chapman, Mrs. Norman Holland, Mrs. J. Dakers Patterson, Mrs. J. M. C. Muir, Miss Hay-Browne, Mrs. P. Currie, Mrs. L. B. Stilwell, of Montreal, Mrs. Henderson, of Chateauguay, and Mrs. G. L. Hulme, of Sherbrooke, are coming to Quebec for the annual meeting of the Quebec Provincial Chapter, I.O.D.E., which will be held Tuesday and Wednesday.

Miss Bulloc and Miss Mary Bulloc have arrived from Halifax to spend the summer months in Quebec.

Mrs. Richard Alleyn was hostess at the lunch hour yesterday in honor of Mrs. Ernest Bertrand, of Montreal.

Miss Molly Usher Jones has returned to Montreal after spending a few days in Quebec with her uncle and aunt, Mr. and Mrs. C. E. Allen Boswell.

Mr. Bryce Scott, who spent the winter in Halifax, has returned to Quebec.

Messrs. Robert Allen and Harry Boswell have returned to Lennoxville to resume their studies at Bishop's College School, after spending Easter in Quebec with their parents, Mr. and Mrs. C. E. Allen Boswell.

Miss Rachel Montreuil has left for Philadelphia, where she will remain for some time.

Miss Helen MacNab, of Halifax, has arrived in Quebec to spend the summer months with the Misses Bulloc, Gomin road.

Members of the executive of the Conservative Women's Association of Quebec, who are in charge of the arrangements for the bridge to be given under the auspices of the Association at the Chateau Frontenac this evening, are Mrs. Charles Fremont, Mrs. H. S. Quart, Mrs. E. Laberge, Mrs. P. J. Jolicoeur, Mrs. W. R. Larue, Mrs. H. V. Gale and Mrs. J. E. Warrington.

Mr. Justice C. E. Dorion and Mrs. Dorion are spending a few days in Montreal, guests at the Windsor Hotel.

LONDON SOCIAL NOTES

(Special to The Gazette.)

London, April 11. — Major and Mrs. Fred Ney have returned from Capri and are again staying at the Stanhope Court Hotel.

Mr. Henry and Lady Anne Hunloke returned today from their Mediterranean cruise to their home at 21 Montague Square.

Viscountess Byng of Vimy has consented to act as the Marchioness of Ormonde's chairman for the ball to be given on April 27th at Portman House in aid of the funds of the Marylebone Conservative Association, which will give many people an opportunity of seeing one of the loveliest houses in London.

Mr. and Mrs. A. D. MacTier, who have been staying at the Connaught Hotel, left London tonight for Scotland, where they will spend Easter with Dr. and Mrs. MacTier. They will return to London on April 20th and will stay at the Stafford Hotel, St. James's Place.

Miss Virginia McLean, the Canadian pianist, who has now completely recovered from her long illness, will broadcast to Canada on May 9th. After filling her summer and autumn engagements she will visit Canada next January.

The Planters' Group of the Royal Empire Society organized a lantern lecture on "Empire Forestry," by Major J. R. Cosgrove, D.S.O., M.C., last Thursday.

Mrs. Howard Ferguson has suspended her Thursday receptions till after Easter.

The Dowager Lady Dufferin was present yesterday at the christening of her twentieth great-grandchild, Marcia, daughter of the Hon. Brinsley and Mrs. Plunkett, at St. Margaret's, Westminster.

Mr. and Mrs. Baldwin will spend Easter with their daughter and son-in-law, the Hon. Arthur and Mrs. Howard, at their country home, Wappingthorn, Sussex.

Mr. and Mrs. Michael Huxley and their children are now settled in the home they have built near Cheltenham. Mrs. Huxley (Ottilie Mills) is a granddaughter of the late Sir Henri Joly de Lotbiniere, of Point Platon, Quebec.

Mr. and Mrs. Dalley gave a thé dansant at the Savoy Hotel for their two sons, Messrs. Fenner and Sam Dalley, last week. Among their guests were Miss Peggy Crerar of Ottawa, Miss Verity Mills, Miss Douglas, Miss Acland, Miss Blennerhassett, Messrs. Bromley Martin, Mills, John Paget, J. Turot, and S. R. Seton.

The High Commissioner for Canada and Mrs. Ferguson will spend a short Easter holiday in motoring in Cornwall and Devon.

Dr. and Mrs. H. P. Biggar and their son, Goldwyn, will spend Easter at Christchurch, Hampshire. Their schoolgirl daughter, Miss Isabelle Biggar, will stay with her cousin, Mrs. Harold Gibson.

SCOUTS TAKE LEAVE OF DR. FRANK ADAMS

Farewell Ceremony Fittingly Staged at Jamboree in Eaton's Building

The Scout movement in Montreal bade farewell to Dr. Frank D. Adams, district commissioner for the last two years, who has served the local organization in several capacities since it was founded in 1910, at a brief ceremony held at the jamboree on the seventh floor of the Eaton building last evening. Dr. Adams' retirement is effective May 1, but the organization chose last night to pay tribute publicly to the services he has rendered to Scouting in Montreal.

In announcing the resignation of Dr. Adams, Alan Ingham, president of the Montreal Scouters' Club, referred to his services to the movement in various capacities over a period of more than 20 years. Mr. Ingham spoke on behalf of the officers, Scouts and Wolf Cubs.

"You have set us a wonderful example," A. B. Morris, assistant commissioner in charge of the southern district, said in addressing Dr. Adams on behalf of the commissioners.

J. E. Macpherson, president of the Montreal District Scout Council, voiced his regrets, and those of the council. "We of the council have depended greatly on Dr. Adams," he said, "and have regarded him as a leader, adviser and the strongest force in Scouting in Montreal for many years."

"I take leave of you with great regret—yet with great hope," Dr. Adams declared in acknowledging the tributes paid to him. "Today the Montreal Scout organization is in a much better position than it has ever been and I feel that now is the time for a younger and more vigorous man to take over my duties and to carry on the work. I appreciate the assistance that has at all times been given to me and the self-sacrifice of the scoutmasters and others who are spending so much time in the development of Scouting."

The ceremony ended with cheers for Dr. and Mrs. Adams and the playing of "For He's a Jolly Good Fellow," by the Vickers Boy Scout Band.

Dr. Adams is leaving shortly for Vancouver where he will superintend arrangements for the Pan-Pacific Scientific Congress to be held there this summer. He will not return to Montreal until early in the fall.

SAFETY LEAGUE ACTIVI

fessor of Sociology, Catholic University of America, "The Divine Example"; 7, James Melton, tenor; string ensemble direction of Victor Young; 7.15, To be announced; 7.30, Joe Moss' Society orchestra—old and new dance hits; 8, Eddie Cantor, master of ceremonies; Rubinoff's orchestra; 9, Manhattan Merry-Go-Round—Jean Sargent, torch singer; David Percy, baritone; orchestra direction Gene Rodemich: Men About Town; 9.30, American Album of Familiar Music; 10, Current Government—David Lawrence; 10.15, Highlights and Shadows—orchestra direction Tom Griselle; 10.45, Sunday at Seth Parker's; 11.15, Don Hall Trio; 11.30, Orchestra Gems; Midnight, Will Osborne and his Village Barn Orchestra.

WJZ—New York (760 Kilocycles.)

12.15 p.m. — Radio City Concert—Radio City Symphony Orchestra direction Erno Rapee; chorus and soloists; 1.15, Travelogues—travel talks by Malcolm La Prade; incidental music; 1.30, Samovar Serenade; 2, Monarch Mystery Tenor; Charles J. Gilchrest, Radio Reporter; Czerwonky Ensemble; 2.15, International Radio Forum; 2.30, The Northwestern Chronicle—dramatic newspaper sketch; 3, Goldman Band—Edwin Franko Goldman, conductor; 4, Dick Daring—A boy of Today—children's dramatic sketch; 4.15, Symphonette — Cyril Pitts, tenor; Josef Koestner's Orchestra; 4.30, National Youth Conference—"Conqueror of Circumstances." Dr. Daniel A. Poling; music direction Keith McLeod; Youth Glee Club; 5, National Vesper—"The Three Wishes." Dr. Paul E. Scherer; music direction Lowell Patton: male quartette; 5.30, Pages of Romance—dramatic sketch; guest artist; 6, Wm. men's octette direction George Dilworth; Fred Hufsmith, tenor; 6.30, Brahms Series Concert—Gordon String Quartette; 7, Borrah Minevitch and his Harmonica Rascals; 7.15, Dr. Howard W. Haggard; 7.30, Great Moments in History—"McCormick and the Reaper" dramatic sketch; orchestra direction Billy Artzt; 8, Land Where the Good Songs Go; 9, Warden Lawes in Twenty Thousand Years in Sing Sing—dramatic sketch; 9.30, Walter Winchell; 9.45, Pickens Sisters—harmony trio; 10, Phil Dewey and his Fireside Songs; 10.15, Lopez and the Two Doctors' Comic Congress; 10.45, Orange Lantern—mystery drama; 11.15, Welcome Lewis, vocalist; orchestra; 11.30, Echoes of the Palisades — Archer Gibson, organist; Chorus; midnight, Dance Nocturne—William Stoess and his orchestra.

"HORACE WEBB" DEAD

Was Regarded As One of World's Greatest Clowns

Fulton, N.Y., April 21. — Once the world's king of clowns, the Canadian-born Horace Webb Baggs, of Fulton, is dead, aged 59. At the height of his career he was the highest paid clown in the show business and was voted the most popular. Under the big top he was known as "Horace Webb." It was he who originated the one-man ladder act and the act in which a man is fired from the mouth of a cannon. Baggs retired 15 years ago.

He died in the Oswego County Sanatorium at Orwell after an illness of several years. His work of making thousands laugh took him through Canada, Mexico, Cuba and the United States with the larger circuses.

Baggs was born in Toronto, on March 20, 1874, a son of Joseph and Ann Baggs, who later moved with him to Fulton. He started with the circus operated by the late Sig Sautelle. Upon his retirement he returned to Fulton and established an elaborate gymnasium and operated a truck gardening business as well.

A philosopher one said that man only thinks when you prevent him from acting.

Ocean Mail Services

Saturday, April 22, 5 p.m., full mail for Denmark, Estonia, Finland, Norway and Sweden and letter and paper mail for Latvia and Lithuania, per Gripsholm from Halifax.

Saturday, April 22, 4 p.m., parcel mail and specially addressed letters and papers for Denmark and Poland, per Kosciuszko from Halifax.

Saturday, April 22, 4 p.m., parcel mail and specially addressed letters and papers for Irish Free State, per Torr Head from Montreal.

Monday, April 24, 4 p.m.; parcel mail and specially addressed letters and papers for Denmark and Sweden per Ragnhildsholm from Montreal.

Monday, April 24, 6 p.m.; letter mail for Great Britain and countries via Great Britain per Europa from New York.

Monday, April 24, 4 p.m.; parcel mail and specially addressed letters and papers for Colombia, Cuba and Jamaica per Andalusia from Halifax.

Tuesday, April 25, 6 p.m.; letters addressed via New York for Great Britain and countries via Great Britain per Berengaria from New York.

Tuesday, April 25, 8 p.m.; full mail for Australia, Fiji, Hawaii, New Zealand per Monterey from San Francisco.

Wednesday, April 26, 4 p.m.; parcel mail and specially addressed letters and papers for South Africa per Lylepark from Montreal.

Thursday, April 27, 4 p.m.; parcel mail and specially addressed letters and papers for Belgium per Beaverdale from Montreal.

Friday, April 28, 6 a.m.; full mail for Great Britain and countries via Great Britain including continent, and parcel mail for Germany and France and countries via France per Montrose from Montreal.

Friday, April 28, 6 a.m.; letters addressed via New York for Great Britain and countries via Great Britain per Ile de France from New York.

Friday, April 28, 4 p.m.; full mail for Barbados, Bermuda, Br. Guiana, Grenada, Leeward Isl., Levis, St. Lucia, St. Vincent, Trinidad, Venezuela per Lady Hawkins from Halifax.

Saturday, April 29, 6 a.m.; full mail for Great Britain and countries via Great Britain, per Duchess of Atholl from Montreal.

Saturday, April 29, 4 p.m.; parcel mail and specially addressed letters and papers for Br. Honduras, Bermuda, Colombia, Jamaica per Cavelier from Halifax.

Sunday, April 30, 4 p.m.; full mail for Antigua, Barbados, Bermuda, Br. Guiana, Dominica, Nevis, St. Kitts St. Lucia, St. Vincent, Trinidad and Venezuela per Colborne from Halifax.

BIRTHS, ENGAGEMENTS, MARRIAGES and DEATHS

$1 Per Insertion Prepaid

BIRTHS

DUNTON—On April 21st, 1933, at the Royal Victoria Maternity Hospital, to Mr. and Mrs. W. E. Dunton, a son.

STAVERT—On April 21st, 1933, at the Royal Victoria Maternity Hospital, to Mr. and Mrs. Ewart Stavert, a daughter.

DEATHS

BENNETT—On April 20th, 1933, at the Royal Victoria Hospital, Joseph Bennett, beloved husband of Margaret Whitehead, of 5468 Hutchison Street, aged 63 years.

Funeral from the Church of the Ascension, Park Avenue, on Saturday, April 22nd, at 3 p.m.

DAY—At his late residence, 7821 De Gaspe Street, on April 19th, 1933, John Fletcher Day, husband of the late Emily F. Brushett, aged 68 years.

Funeral from the Chapel of Jos. C. Wray & Bro., 1234 Mountain Street, at 2 p.m., Saturday, to Mount Royal Cemetery.

ENGLISH—At her late residence, 14 Bertram Street, Birtley, England, on Friday, April 7th, 1933, Ann H. P. English, aged 71 years, widow of the late B. Burton English, and beloved mother of Norman English.

FORBES—In this city, on April 21st, 1933, Agnes Emma, beloved daughter of Mr. and Mrs. George Forbes, of 746 Fulford Street.

Funeral from the Chapel of Jos. C. Wray & Bro., 1234 Mountain Street, at 10 a.m., Monday, to Mount Royal Cemetery.

HOWLETT—At his residence, 8631 de Grosbois Street on April 21st, 1933, Thomas Beasley Howlett, in his 70th year.

Funeral from above address on Monday, April 24th, at 2 p.m.

MAINWARING—At his late residence, 148 Pine Avenue, St. Lambert, on April 21st, 1933 Mary Jane Porter, beloved wife of Robert Mainwaring, aged 57 years.

Funeral from the Chapel of Jos. C. Wray & Bro., 1234 Mountain Street, at 1 p.m., Saturday, to Mount Royal Cemetery.

Crewe Chronicle and Fleetwood Chronicle, England, papers please copy.

McARTHUR—At his residence, at Brockville, Ont., on Friday, April 21st, 1933, James D. McArthur, in his 86th year.

Funeral from the William Wray Chapel, 2075 University Street, on Saturday, April 22nd, at 4.30 p.m., to Mount Royal Cemetery.

SAUNDERS—At St. Mary's Hospital, on April 21st, 1933, Arthur Saunders, aged 45 years.

Funeral from the Chapel of Jos. C. Wray & Bro., 1234 Mountain Street, at 11 a.m., on Tuesday, April 25th.

WILLIAMS—At her late residence, 7530 Durocher Avenue, on Friday, April 21st, 1933, Margaret Ann Pugh, widow of the late Owen Williams, aged 84 years.

Funeral service at the Chapel of G. Armstrong & Co., 3426 Park Avenue, on Saturday, April 22nd, at 2 p.m.

WINDER—On April 20th, 1933, at the Montreal General Hospital, Thomas Francis Winder, son of the late John Winder, and beloved husband of Jeanette Black.

Funeral from the William Wray Chapel, 2075 University Street, on Saturday, April 22nd, at 3.30 p.m.

WYER—At her late residence, 535 Ash Avenue, on April 19th, 1933, Agnes Dickson, beloved wife of Francis E. Wyer.

Funeral (private) from the Chapel of Jos. C. Wray & Bro., 1234 Mountain Street, on Saturday, April 22nd, to Mount Royal Cemetery.

Toronto, Ont., papers please copy.

St. George's Lodge, No. 440, E.R., A.F. & A.M.

FUNERAL NOTICE

The Brethren of the above Lodge are requested to attend an emergent communication to be held in the Lodge Rooms, Royal Bank Chambers, corner of Seigneurs and Notre Dame Streets West, on Saturday, April 22nd, at 2.30 p.m., to attend the Funeral of our late Brother, T. F. Winder, leaving the William Wray Chapel, 2075 University Street, at 3.30 p.m.

Brethren of Sister Lodges are invited to attend.

By Command of the W.M.,
E. W. MANTHORP,
Regalia. Secretary.

ELGIN LODGE, No. 7, A.F. & A.M., G.R.Q.

The Members of the above Lodge are requested to attend an emergent meeting at the Masonic Memorial Temple, on Saturday, April 22nd, 1933, at 2 p.m., to attend the Funeral of our late Brother, Brother Joseph Bennett.

Brethren of Sister Lodges are invited to attend.

By Command of the W.M.,
D. C. WRIGHT,
Regalia. Secretary.

PROVINCE OF QUEBEC, District of Montreal. — IN THE SUPERIOR COURT. — No. D-117551 — ISRAEL MEUNIER, DIT LAGACE, Innkeeper, of the City and District of Montreal, Plaintiff, vs. THOMAS KIRKWOOD, of the City and District of Montreal, Defendant, and JAMES K. McKINNON, of Marmora, in the Province of Ontario, and TELESPHORE BRASSARD, Registrar, of the Registry Division of [illegible] Mis-en-cause.—

AN OBLIGATION TO TOMORROW

EDITOR'S NOTE: *A little more than a year ago* The Saturday Review *published the full text of Dr. Albert Schweitzer's "Declaration of Conscience," a plea to the world's peoples to inform themselves about the runaway nuclear-arms race. In particular, Dr. Schweitzer called attention to the hazards involved in nuclear explosions.*

Last fall, when the editor of The Saturday Review *saw Dr. Schweitzer at his home in the Alsace, the philosopher-theologian-physician expressed grave concern about the possibility of a breakdown in the London talks then being held by the major powers on the subject of arms control. Dr. Schweitzer doubted that the nations would accept any such controls in the absence of a genuine demand by world public opinion. His apprehensions turned out to be correct.*

After Dr. Schweitzer returned to Lambarene last year, he continued his correspondence on the human crisis with leading scientists, historians, and thinkers in various parts of the world. This exchange of ideas and information fortified him in his view of the danger. Several months ago, he began to write an enlarged appeal, going beyond the question of nuclear experimentation into the general problem of world peace. He worked under difficult conditions, often late at night after the sounds had quieted down at his jungle hospital. His right hand had been injured as the result of a fall, and the splints on one of his fingers impeded his writing.

The new appeal, when completed, was divided into three parts, each dealing in a detailed way with separate aspects of the world problem. Like the Declaration of 1957, it was sent to Radio Oslo, Norway, for world-wide distribution to newspapers and radio networks.

Once again, The Saturday Review *feels privileged to present the full text of Dr. Schweitzer's message. Dr. Schweitzer has given the editors permission to translate and edit the text from the German. The editors wish to emphasize, therefore, that any flaws in language or structure are chargeable to them.*

By ALBERT SCHWEITZER

IN APRIL of last year I raised my voice, together with others, to draw attention to the great danger of radioactive poisoning of the air and the earth, following tests with atomic bombs and hydrogen bombs. With others, I appealed to the nuclear powers to come to a workable agreement to stop the tests as soon as possible, at the same time declaring their genuine desire to renounce the use of nuclear weapons.

At that time there appeared to be reasonable hope that this step would be taken. It was not. The negotiations in London last summer achieved nothing. The conference arranged by the United Nations in the autumn of last year suffered the same fate when the Soviet Union withdrew from the discussions.

The question of nuclear arms control, however, cannot be put aside. Any discussions among the major nations will have to consider this problem.

As a first step in any comprehensive plan for workable arms control, the proposal for a cessation of nuclear tests has frequently been advanced.

One might have thought that it would be comparatively simple for all those involved to agree on this first step. No nuclear power would have to sacrifice any of the atomic weapons in its possession. The disadvantage of not being able to try out new bombs or nuclear devices would be the same for all.

The United States and Great Britain have been reluctant to take the first step. They spoke against it when the matter was discussed in Spring 1957. Since then many statements have been issued claiming that the radioactivity resulting from nuclear tests is not dangerous. For example, in an official statement coming from the United States, we read the following: "The necessary steps should be taken to correct the present confusion of the general public [with respect to the effects of testing]. . . . The present and potential effects on heredity from the gradual increase of radioactivity in the air are kept within tolerable limits. . . . The possibility of harmful effects which people believe to be outside control has a strong emotional impact. . . . The continuation of nuclear tests is necessary and justified in the interests of national security."

Despite these assurances, however, people are becoming increasingly apprehensive concerning the possible dangers resulting from nuclear tests.

The reasoning behind the somewhat obscure statement that "the effects on heredity from the gradual increase of radioactivity in the air are kept within tolerable limits" is that the number of deformed children that will be born as a result of the harm done to the sexual cells supposedly will not be large enough to justify the stopping of the tests.

During this campaign of reassurance, a prominent American nuclear physicist even declared that the luminous watchdials in the world represent a greater danger than the radioactive fall-out of nuclear tests until now.

This campaign of reassurance sets up anticipations of

glad tidings to the effect that science has succeeded in making the prototype of a hydrogen bomb with a considerably reduced dangerous radioactive fall-out. The new explosive is called a "clean" hydrogen bomb. The old type is being designated as the "dirty" bomb.

The so-called "clean" hydrogen bomb differs from the other in having a jacket made of a material which does not release immense quantities of radioactive elements at the enormous explosion temperature. That is why it is less harmful, as regards radioactivity, than the usual ones.

However, the new, highly-praised hydrogen bomb is—let it be said in passing—only relatively clean. Its trigger is an uranium bomb made of the fissionable uranium-235—an atomic bomb as powerful as the one dropped over Hiroshima. This bomb, when detonated, also produces radioactivity, as do the neutrons released in great numbers at the explosion.

Earlier this year, in an American newspaper, Edward Teller, the father of the "dirty" hydrogen bomb, sings a hymn of praise to the idylic nuclear war to be waged with completely clean hydrogen bombs. He insists on a continuation of the tests in order to perfect this ideal bomb.

Here are two stanzas from Edward Teller's hymn to idylic nuclear warfare:

"Further tests will put us into a position to fight our opponents' war machine, while sparing the innocent bystanders."

"Clean weapons of this kind will reduce unnecessary casualties in a future war."

The idea of limited nuclear war is a contradiction in terms. Each side will use all the power at its disposal in an attempt to annihilate the enemy. The U.S. Department of Defense has quite recently declared that the irradiation of whole areas has become a new offensive weapon.

THE "clean" hydrogen bomb may be intended, I fear, more for display-case purposes than for use. The intention seems to be to convince people that new nuclear tests will be followed by less and less radiation and that there is no real argument for the discontinuation of the tests.

Those who think that the danger created by nuclear tests is small mainly take the air radiation into consideration, and persuade themselves to believe that the danger limit has not yet been reached.

The results of their arithmetic are not so reliable, however, as they would have us believe. Through the years the toleration limit for radiation has had to be lowered several times. In 1934 it was 100 radiation units per year. At present the limit is officially put at 5. In many countries it is even lower. Dr. Lauriston Taylor (USA), who is regarded as an authority on protection against radiation, holds—like others—that it is an open question whether there is anything called a harmless amount of radiation. He thinks that we can only speak of an amount of radiation which we regard as tolerable.

We are constantly being told about a "maximum permissible amount" of radiation. What does "permissible" mean? And who has the right to "permit" people to be exposed to these dangers?

When speaking about the risk of radiation we must take into consideration not only the radiation coming from the outside, but also the radioactivity that gets into our bodies.

What is the source of this radioactivity?

The radioactive materials put into the air by nuclear tests do not stay there permanently. In the form of radioactive rain—or even radioactive snow—they fall to the earth. They enter the plants through leaves and roots and stay there. We absorb them by drinking milk from cows or by eating the meat of animals which have fed on it. Radioactive rain contaminates our drinking water.

The most powerful radioactive poisoning occurs in the areas between the Northern latitudes 10° and 60°, because of the numerous nuclear tests conducted mainly in these latitudes by the Soviet Union and the United States.

The radioactive elements absorbed over the years by our body are not evenly distributed in the cellular tissue, but are deposited and accumulated at certain points. From these points internal radiation takes place, causing injuries to particularly vulnerable organs. What this kind of radiation lacks in strength is made up for by its longevity, working as it does for years, day and night.

IT IS a well-known fact that one of the most widespread and dangerous elements absorbed by us is strontium-90. It is stored in the bones and emits from there its rays into cells of red bone marrow, where the red and white corpuscles are made. If the radiation is too great, blood diseases—fatal in most cases—are the result.

The cells of the reproductive organs are particularly sensitive. Even relatively weak radiation may lead to fatal consequences.

The most sinister aspect of internal as well as external radiation is that years may pass before the evil consequences appear. Indeed, they make themselves felt, not in the first or second generation, but in the following ones. Generation after generation, for centuries to come, will witness the birth of an ever-increasing number of children with mental and physical defects.

It is not for the physicist, choosing to take into account only the radiation from the air, to utter the final word on the dangers of nuclear tests. That right belongs to the biologists and physicians who have studied internal as well as external radiation, and to those scientists who pay attention to the facts established by the biologists and physicians.

The declaration signed by 9,235 scientists of all nations, handed to the Secretary General of the U.N. by Dr. Linus Pauling on January 13, 1958, gave the campaign of reassurance a serious blow. The scientists declared that the radioactivity gradually created by nuclear tests represents a grave danger for all parts of the world, particularly serious because its consequences will be an increasing number of deformed children in the future. For this reason they insist on an international agreement putting an end to the nuclear tests.

The declaration signed by the 9,235 scientists did well in stressing the danger of the harmful effects of nuclear tests on future generations which, according to biologists and physicians, will be the result of the radiation to which we are being exposed.

We must not disregard our responsibility to guard

—Erica Anderson.

against the possibility that thousands of children may be born with the most serious mental and physical defects. It will be no excuse for us to say later that we were unaware of that possibility. Only those who have never been present at the birth of a deformed baby, never witnessed the whimpering cries of its mother, should dare to maintain that the risk of nuclear testing is a small one. The well-known French biologist and geneticist Jean Rostand calls the continuation of nuclear tests "a crime into the future" (*le crime dans l'avenir*). It is the particular duty of women to prevent this sin against the future. It is for them to raise their voices against it in such a way that they will be heard.

No longer can we take any comfort from the fact that the scientists do not agree on the question of the danger of radiation, or that we must await the decision of international bodies before making positive statements about radiation. Despite all the claims of safety, the truth about the danger of nuclear explosions marches imperturbably along, influencing an ever-increasing section of public opinion. In the long run, even the most well-organized propaganda can do nothing against the truth.

It is a strange fact that few people have taken into consideration that the question of nuclear testing is not one which concerns the nuclear powers exclusively, a question for them to decide at their pleasure. Who has given these countries the right to experiment, in times of peace, with weapons involving the most serious risks for the whole world? What has international law—enthroned by the United Nations and so highly praised in our time—to say on this matter? Does it no longer look out on the world from its temple? Then take it out, so that it may face the facts and do its duty accordingly.

International law should consider at once the compelling case of Japan. That country has suffered heavily from the effects of nuclear tests. The radioactive clouds created by the Soviet tests in Northeast Siberia and by the American tests in the Pacific Ocean are carried by the winds over Japan. The resultant radioactive poisoning is considerable. Powerful radioactive rainfalls are quite common. The radioactive poisoning of the soil and the vegetation is so heavy that the inhabitants of some districts ought to abstain from using their harvest for food. People are eating rice contaminated by radioactive strontium, a substance particularly dangerous for children. The ocean surrounding Japan is also at times dangerously radioactive, and thereby the very food supply of the country—in which fish has always played an important part—is being threatened.

As every new nuclear test makes a bad situation worse, the Japanese ministers, when hearing of plans for new tests to the north or south of Japan, have presented their country's urgent appeal in Washington or Moscow, beseeching the American or Soviet authorities to give up their plans.

We generally learn about these appeals and the refusals through short newspaper items. Unfortunately, there have been few responsible editorials drawing our attention to the stories behind the news—the misery of human beings who are now in jeopardy. In that way, we and the press are guilty of a lack of compassion. Even guiltier, however, is international law, which has kept silent and indifferent on this question, year after year.

It is high time to recognize that the question of nuclear testing is a matter for world law to consider. Mankind is imperiled by the test. Mankind insists that they stop, and has every right to do so.

If anything is left of international law in our civilization, then the nations responsible for nuclear tests must renounce them immediately, without making this dependent on agreements with respect to the larger questions of general disarmament. Nuclear tests have nothing to do with disarmament. The nations in question will continue to have those weapons which they now have.

There is no time to lose. New tests must not be allowed to increase the already existing danger. It is important to realize that even without new tests the danger will increase during the coming years: a large part of the radioactive elements flung up in the atmosphere and stratosphere at the nuclear experiment is still there. It will come down only after several years—probably about fifteen.

The immediate renunciation of further tests will create a favorable atmosphere for talk on controlling the stockpiles of nuclear weapons and banning their use. When this urgently necessary step has been taken, such negotiations can take place in peace.

That the Soviet Union has announced its willingness to stop its tests is of great importance. The world now looks to the United States and Great Britain for the kind of moral initiative and action that go along with great leadership.

PART II

Today we are faced with the menacing possibility of an outbreak of an atomic war between Soviet Russia and the United States. It can only be averted if the two powers decide to renounce atomic arms.

How did this situation arise?

In 1945 America succeeded in producing an atomic

bomb with uranium-235. On August 6, 1945, this bomb was dropped on Hiroshima. Another atomic bomb was dropped on Nagasaki on August 9.

When America came into the possession of such a bomb it held a military advantage over other countries.

In July 1949 the Soviet Union also test-exploded its first nuclear bomb. Its power was approximately equal to the American bomb then existing.

On October 3, 1952, England exploded its first atomic bomb on the Isle of Montebello (situated on the north-west coast of Australia).

In the quest for nuclear supremacy, both the Soviet Union and the United States moved towards the development of a nuclear weapon many times more powerful—the hydrogen bomb. A series of tests was undertaken by the United States in the Marshall Islands beginning in May 1951, and culminating in a successfully exploded hydrogen bomb in March 1954.

The actual power of the explosion was far stronger than had been originally calculated.

AT APPROXIMATELY the same time, the Soviet Union also started its experimentations, exploding its first hydrogen bomb on August 12, 1953.

Today, guided missiles can be launched from their starting points and directed with accuracy at distant targets. The larger explosives are carried by missiles containing the fuel necessary for their propulsion. The gases from this fuel rush with tremendous velocity through a narrow opening. Science is in the process of discovering a fuel which is similar and more efficacious to deal with.

It is said that the Soviet Union already has available rockets with a range up to 600 miles. Soon to come are rockets with a range up to 1,080 miles—if they are not already in use.

It is said that America is attempting to develop rockets with a range of 1,440 miles.

Whether the intercontinental ballistic missile, with its range of 4,800 miles, already exists cannot be ascertained. The Soviet Union has claimed it already has such a missile.

Even without respect to intercontinental ballistic missiles, submarines could launch nuclear attacks on the United States.

The long-range rockets attain unbelievable speed. It is expected that an intercontinental rocket would not take more than twenty minutes to cross the ocean with a payload of nuclear explosive weighing from one to five tons.

How could an atomic war break out today? Not long ago there was talk of local or limited wars that could be contained. But today there is little difference between a local war or a global war. Rocket missiles will be used up to a range of 1,440 miles. The destruction should not be underestimated, even if caused only by a Hiroshima-type bomb.

It can hardly be expected that an enemy will refrain from using atomic bombs or the most devastating hydrogen bombs on large cities at the very outset of a war. One hydrogen bomb now exists that is a thousand times more powerful than the atomic bomb. It will have a destructive radius of many miles. The heat will be 100 million degrees. One can imagine how large would be the number of city-dwellers who would be destroyed by the pressure of the explosion, by flying fragments of glass, by heat and fire and by radioactive waves, even if the attack is only of short duration. The deadly radioactive contamination, as a consequence of the explosion, would have a range of some 45,000 square miles.

An American general has said to some Congressmen: "If at an interval of ten minutes 110 hydrogen bombs are dropped over the USA there would be a casualty list of about 70 million people; besides, some thousands of square miles would be made useless for a whole generation. Countries like England, West Germany, and France could be finished off with fifteen to twenty hydrogen bombs."

President Eisenhower has pointed out, after watching maneuvers under atomic attack, that defense measures in a future atomic war become useless. In these circumstances all one can do is to pray.

Indeed, not much more can be done in view of an attack by hydrogen bombs than to advise all people living to hide beneath a very strong wall made of stone or cement, and to throw themselves on the ground and to cover the back of their heads, and the body if possible, with cloth. In this way it may be possible to escape annihilation and death through radiation. It is very important that the immediate survivors are given non-radioactive food and drink, and that they be removed immediately from the radioactive district.

It is impossible, however, to erect walls and concrete ceilings of adequate thickness to cover an entire city. Where would the material and the means come from? How would a population find time even to run to safety in such bunkers?

In an atomic war there would be neither conqueror nor vanquished. During such a bombardment both sides would suffer the same fate. A continuous destruction would take place and no armistice or peace proposals could bring it to an end.

When people deal with atomic weapons, it is not a matter of superior arms which will decide the issue between them, but only: "Now we want to commit suicide together, destroying each other mutually . . ."

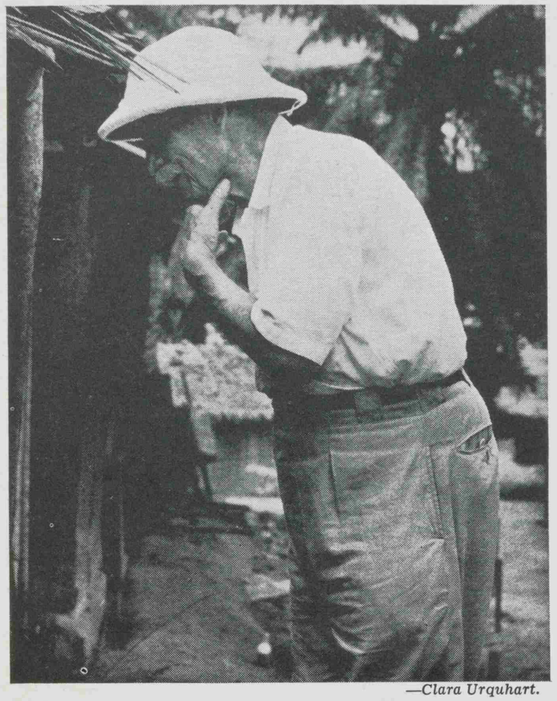
There is a reason for an English M.P. saying: "He who uses atomic weapons becomes subject to the fate of a bee, namely, when it stings it will perish."

Radioactive clouds resulting from a war between East and West would imperil humanity everywhere. There would be no need to use up the remaining stock of atomic and hydrogen bombs now running literally into the thousands.

A nuclear war is therefore the most senseless and lunatic act which could ever take place. This must be prevented.

When America had its atomic monopoly, it was not necessary to equip its allies with nuclear weapons. Owing to the end of the monopoly, however, this situation is changing. A whole family of nuclear weapons now exists that can be fitted into the military capability of smaller nations.

As a result, the United States is considering a de-



—Clara Urquhart.

parture from its stated principle not to put atomic weapons into the hands of other countries. If it does so, this could have the gravest consequences. On the other hand, it is comprehensible that the United States wishes to supply the NATO countries with such new weapons for defence against the Soviet Union. The existence of such arms constitutes a new cause of war between the Soviet Union and the U.S., one that did not exist before. Thus, the ground is laid open for a nuclear conflict on European soil. The Soviet Union can be reached with long-range rockets from European soil, as far as Moscow and Kharkov, up to 2,400 miles away. Similarly, London, Paris, and Rome are within easy reach of Soviet rocketry.

Rockets of an average range may be used for defense purposes by Turkey and Iran against the Soviet Union. They could penetrate deeply into its country with arms accepted from America.

The Soviet Union is countering those measures. Both America and the Soviet Union may now seek alliances with the Middle East by offering those countries various kinds of financial support. Therefore, events in the Middle East could endanger the peace of the world.

The danger of an atomic war is being increased by the fact that no warning would be given in starting such a war. Indeed, it could erupt merely on the basis of some incident. Thus, the time factor enters—the side that attacks first would have the initial advantage over the attacked. At the very start, the attacked would find himself sustaining losses which would reduce his fighting capacity considerably.

As a result, one has to be on the alert all the time. This factor constitutes an extreme danger in the event of a sudden outbreak of an atomic war. When one has to act with such speed, he has to reckon with the possibility that an error may occur on what is registered on the radar screen, and that this could result in the outbreak of an atomic war.

Attention was drawn to this danger by the American General Curtis LeMay. Quite recently the world found itself in such a situation. The radar station of the American Air Force and American Coastal Command indicated that an invasion of unidentified bombers was on the way. Upon this warning, the general who was in command of the strategic bomber force ordered that reprisal bombardment should be made. However, realizing that he was taking a great responsibility, he hesitated. Shortly afterwards, it was pointed out that the radar stations had committed a technical error. What could have happened if a less balanced general had been in his place!

In the future such dangers are likely to increase. Owing to the fact that small rockets exist which pass through the air with terrific speed and are over the target within a few minutes—defense possibilities become very limited. Only seconds remain to identify the markings on the radar screen, so that the counter-attack can spring into being. The theoretical defense consists in sending out missiles to explode the attacking missiles of the enemy before they complete their job, and also in releasing bombers with a view to destroying the ramps from which they are launched.

Such split-second operations cannot be left to the human brain. It works too slowly. The job has therefore been entrusted to an electronic brain.

Such are the heights of our civilization that a cold electronic brain rather than the moral conscience of man may decide human destiny. Are we so certain that an arithmetrical or mechanical decision is really superior? The mechanism of the electronic brain may become faulty. It is dependent on the absolute reliability of its complicated functions. Everything has to click to the minutest detail.

UNDER the circumstances, the greater the number of countries, large or small, that become part of the nuclear arms terror the greater the terror. Naturally, America must assume that the weapons it entrusts to other nations will not be used irresponsibly. But accidents can happen. *Who* can guarantee that there may not be a "blacksheep" acting on his own, without troubling about the consequences? Who is *able* to keep *all* countries under a situation of rational control? The dam is punctured and it may break down.

That such worries have become very real is shown by the reasoning of the 9,235 scientists on January 13, who petitioned the United Nations regarding the cessation of atomic tests. The statement says: "As long as atomic weapons remain in the hands of the three great powers, agreement on control is possible. However, if the tests continue and extend to other countries in possession of atomic weapons, the risks and responsibilities in regard to an outbreak of an atomic war becomes all the greater. From every point of view the danger in a future atomic war becomes all the more intense, so that an urgent re-

nunciation of atomic weapons becomes absolutely imperative."

America has wisely declared that its objective is to outlaw nuclear weapons. Yet, at the same time, America seems to be moving away from the measures necessary to achieve it. America insists that the missiles it offers to other countries be accepted as quickly as possible. It wishes to hold such a position as to be able to maintain peace by nuclear deterrent. It happens, however, that most of the NATO countries are not in any hurry to acquire such weapons. An increasingly strengthening public opinion is the cause of this.

PUBLIC opinion in Europe has been convinced during recent months that under no circumstances should Europe be allowed to become a battlefield for an atomic war between the Soviet Union and America. From this position it will not deviate. The time is past when a European power could plan secretly to establish itself as a big power by manufacturing atomic weapons exclusively for its own use. In view of the fact that no public opinion would agree to such an undertaking, it becomes senseless even to prepare secretly for achieving such a plan.

Gone, too, is the time when NATO generals and European governments can decide on the establishments of launching sites and stockpiling of atomic weapons. In view of the fact that the dangers of atomic war and its consequences cannot be avoided, political procedure as employed hitherto can no longer be considered.

Only agreements that are sanctioned by public opinion are now valid.

PART III

What about the negotiations that could lead to the renunciation of nuclear weapons?

One reads and hears that the success of the projected Summit Conference must depend entirely on its every detail being diplomatically prepared beforehand. The best diplomacy is objectivity. One good way of preparing for a conference (if a respectful and well-meaning criticism is permissible) would be for the statesmen and other representatives to make a change from their present undiplomatic way of dealing with each other and to become diplomatic. Many unnecessary, thoughtless, discourteous, foolish, and offensive remarks have been made by both sides, and this has not been advantageous to the political atmosphere.

It would be fitting if those who have the authority to take the responsibility, and not those who have only nominal authority and who cannot move an inch from their instructions, would confer together.

It would be fitting to go ahead with the conference. For more than five months East and West have talked and written to one another, without any conclusions as to the date and the work program being reached. Public opinion everywhere is finding it difficult to accept this state of affairs and is beginning to ask itself whether a conference which comes into being so limpingly has any hope of really achieving anything.

It would be fitting to hold the conference in a town

—Erica Anderson.

in some neutral European country, for example, Geneva, as was the case in 1955.

It would be fitting that at this conference only questions that have to do directly with the control and renunciation of nuclear weapons should be discussed.

It would be fitting if not too many people were present at the summit meeting. Only the highest personalities of the three nuclear powers together with their experts and advisers should take their seats there.

Attendance could also be opened on a consultative basis to the representatives of those peoples who—like the NATO countries with America—have connections in nuclear matters; they could then state their opinions on the decisions that hold such grave consequences also for them.

Apart from this, experience teaches us that unnecessarily large attendance brings no advantage to a conference.

THE Summit Conference, therefore, is in no way an international or half international one, even though its decisions are of great importance to the whole of mankind.

The three nuclear powers and they alone must decide, in awareness of their responsibility to their peoples and to all mankind, whether or not they will renounce the testing and the use of nuclear weapons.

In regard to the planning of the conference, impartiality may justify one remark, which is that to date such planning has not been done objectively, and has therefore led nowhere. This leads to the thought that the outcome of a Summit Conference is bound to reflect what went into it.

What is the difference between the partial and the impartial; the fitting and the unfitting in this matter? It lies in the answer to the question on what basis the three nuclear powers decide whether or not to renounce the testing and the use of nuclear weapons.

The unobjective reply would be that the decision will

depend on whether an agreement is first reached on comprehensive disarmament or not.

This is a false logic; it presumes that there could be an agreement acceptable to both the East and the West on this issue. But previous negotiations have shown that this is not to be expected; they became stalled right at the start because East and West have been unable to reach agreement even on the conditions under which such discussions should take place.

The anticipated procedure itself is by its very nature not impartial. It is based on false logic. The two vital issues so essential to the very existence of mankind—the cessation of tests and the disposal of nuclear weapons—cannot be made dependent on the Heavens performing the impossible political miracle that alone could insure that none of the three nuclear powers would have any objections to a complete agreement on disarmament.

The fact is that the testing and use of nuclear weapons carry in themselves the absolute reasons for their being renounced. Prior agreement on any other conditions cannot be considered.

Both cause the deepest damage to human rights. The tests do harm to peoples far from the territories of the nuclear powers—endangering their lives and their health—and this in peace time. An atomic war, with its resultant radioactivity, would make the land of peoples not participating in such a war, unlivable. It would be the most unimaginably senseless and cruel way of endangering the existence of mankind. That is why it must not be allowed to happen.

The three nuclear powers owe it to themselves and to mankind to reach agreement on these absolute essentials without first dealing with prior conditions.

The negotiations about disarmament are therefore not the forerunner of such agreement but the outcome of it. They start from the point where agreement on the nuclear issues has been reached, and their goal is to reach the point where the three nuclear powers and the peoples who are connected with them must agree on guarantees that will seek to avert the danger of a threat of a non-atomic nature taking the place of the previous danger. Everything that the diplomats will have done objectively to prepare the preliminaries to the conference will keep its meaning even if it will be used not before renunciation, but as the result of it.

Should agreement be reached on the outlawing of nuclear weapons, this by itself will lead to a great improvement in the political situation. As a result of such an agreement, time and distance would again become realities with their own right.

Nuclear weapons, used in conjunction with missiles, change a distant war to a war fought at close range. The Soviet Union and the United States have become next-door neighbors in the modern world but live in constant fear of their lives every minute.

But if nuclear arms should be abolished, the proximity factor would be made less explosive.

Today America has her batteries of nuclear missiles readily available in Europe. Europe has become a connecting land strip between America and Russia, as if the Atlantic had disappeared and the continents had been joined.

But if atomic missiles are outlawed on the basis of effective and enforceable control, this unnatural state of affairs would come to an end. America would again become wholly America; Europe wholly Europe; the Atlantic again wholly the Atlantic Ocean.

THE great sacrifices that America brought to Europe during the Second World War and in the years following it will not be forgotten. The many-sided and great help that Europe received from her and the thanks owing for this will not be forgotten.

But the unnatural situation created by the two world wars, that led to a dominating military presence in Europe, cannot continue indefinitely. It must gradually cease to exist—both for the sake of Europe and for the sake of America.

Now there will be shocked voices from all sides: What will become of poor Europe if American atomic weapons no longer defend it from within and from without? Will Europe be delivered to the Soviet? Must it be prepared to languish in a Communist-Babylonian imprisonment for long years?

What Europe and the Europeans have to agree about is that they belong together for better or for worse. This is a new historical fact that can no longer be by-passed politically.

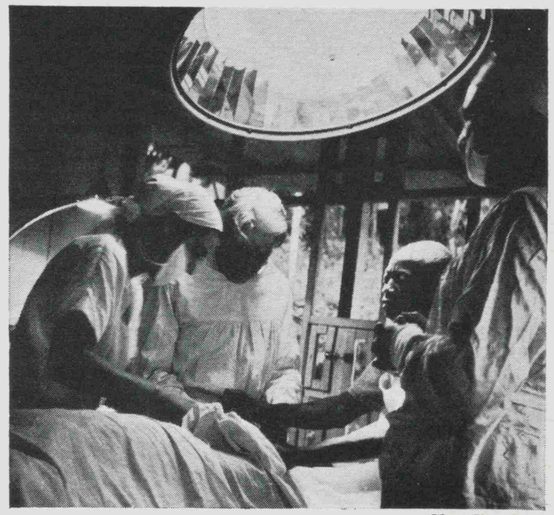
Another factor that must be recognized politically is that it is no longer a question of subjugating peoples, but learning to get along with them intellectually, culturally, spiritually.

A Europe standing on its own has no reason to despair.

Disarmament discussions between the three nuclear powers must seek the guarantees that can bring about actual, total and durable disposal of nuclear weapons. The question of control and safeguards is a vital one. Reciprocal agreement will have to be reached about allowing international commissions to inspect and investigate on national soil.

One talks of giving aircraft belonging to a world police the right to fly at medium and high altitudes for purposes of aerial inspection.

One asks to what extent a state would be willing to



—Clara Urquhart.

subject itself to such control? It may be said that unfortunate incidents could easily occur as a result. And what about the power that should be entrusted to such a world control? Even the widest form of such control could never insure that everywhere and all the time war could be avoided. But it represents a reasonable basis on which, given time and some relaxation of tension, a workable world system of security might be built.

The same applies also in another matter. As a result of renouncing nuclear arms, the Soviet Union's military might insofar as Europe is concerned would be less affected than that of America. There would remain to the Soviet the many armed divisions with conventional weapons; with those divisions it could easily over-run the NATO states in western Europe—particularly Western Germany—without it being possible for anyone to come to their aid. With this in mind, the Soviet Union should agree in the course of disarmament negotiations to reduce her army, and to commit herself not to undertake steps against Germany. But here, too, no manner of detailed agreements and internationally guaranteed disarmament agreements would be enough. Therefore, we must strive continually to improve the situation, building brick by brick.

We live at a time when the good faith of peoples is doubted more than ever before. Expressions putting into doubt the trustworthiness of the next nation are bandied back and forth. They are based on what happened in the two world wars when the nations experienced dishonesty, injustice, and inhumanity from one another. How can a new trust come about?

We cannot continue in a situation of paralyzing mistrust. If we want to work our way out of the desperate situation in which we find ourselves another spirit must enter into the people. It can only come if the awareness of its necessity suffices to give us strength to believe in its coming. We must presuppose the awareness of this need in all the peoples who have suffered along with us. We must approach them in the spirit that we are human beings, all of us, and that we feel ourselves fitted to feel with each other; to think and to will together in the same way.

The awareness that we are all human beings together has become lost in war and politics. We have reached the point of regarding each other as only members of a people who is allied with us or against us, and our attitudes, prejudices, sympathies, or antipathies are all conditioned by that fact. Now we must rediscover the fact that we—all together—are human beings, and that we must strive to concede to each other what moral capacity we have.

That way we can begin to believe that also in other peoples there will arise the need for a new spirit, and that can be the beginning of a feeling of mutual trustworthiness towards each other. The spirit is a mighty force for transforming things. Let us have hope that the spirit can bring people and lands back to an awareness of enlightenment.

At this stage we have the choice of two risks. The one consists in continuing the mad atomic arms race with its danger of unavoidable atomic war in the near future. The other is in the renunciation of nuclear weapons, and the hope that America and the Soviet Union, and the peoples associated with them, will manage to live in peace. The first holds no hope of a prosperous future; the second does. We must risk the second.

In President Eisenhower's speech of November 7, 1957, we find the following: "What the world needs more than a gigantic leap into space is a gigantic leap into peace."

This gigantic leap consists in finding the courage to hope that the spirit of good sense will arise in all peoples and in all lands, a spirit sufficiently strong to overcome the insanity and the inhumanity.

Once agreement on renunciation of nuclear arms has been reached it would be the responsibility of the United Nations to undertake to see that now, as in the future, they would neither be made nor used. The danger that one or another people might attempt to manufacture nuclear weapons will have to be kept in mind for a long time.

The future holds many difficult problems. The most difficult of these will be the rights of access of overpopulated countries to neighboring lands.

But if in our time we renounce nuclear arms we will have taken the first step on the way to the distant goal of the end to war itself. If we do not do this we remain on the road that leads to atomic war and misery in the near future.

Those who are to meet at the Summit must be aware of this, so that they can negotiate with propriety, with the right degree of seriousness, and with a full sense of responsibility.

The Summit Conference must not fail. The will of mankind will not permit it.

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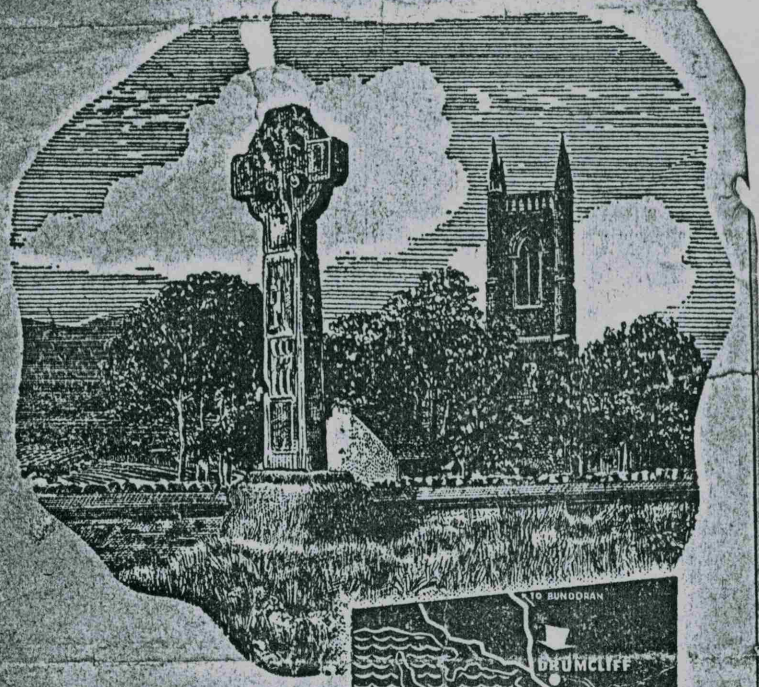
MOTORING IN IRELAND



No. 4

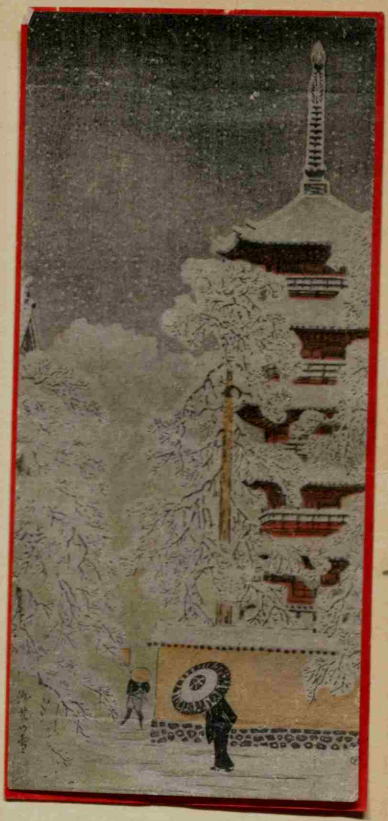
Drumcliff Churchyard, Co. Sligo.

It would be impossible to find in Ireland a more beautiful countryside than secluded Drumcliff, situated five miles north of Sligo and flanked on either side with noble mountains, notably the Benbulben range. About the year 574 St. Columba founded one of his many churches here and until the 14th century peace and prosperity reigned. In 1416 the church was plundered, the Abbott burned and the decline of Drumcliff quickly set in. Remaining to attest its ancient importance are the base of a round tower dating back to the 10th century and a remarkable cross decorated with sculptured ornaments and figures. Here too, in the spot of his desire, the Remains of the poet, W. B. Yeats, have been interred. Of Drumcliff it may well be said, with Yeats:

"all things remain in God."

Happy motoring starts with ESSO

K.A.A.



CALENDAR

FOR

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To Dr. Douglas.

Wishing you a Merry Christmas
and Happy New Year.

Sylvia Wadsworth.