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THE DEDICATION OF THE McDONALD OBSERVATORY

Edited by Dr. OTTO STRUVE

DIRECTOR OF THE YERKES AND McDONALD OBSERVATORIES

THE dedication of the W. J. McDonald Observatory of the University of Texas, on Mount Locke, near Fort Davis, Texas, took place in the afternoon of Friday, May 5. More than 400 invited guests from all parts of the United States, from Canada, Mexico and some European countries were present on the observing floor of the 62-foot dome. The speakers were located on the observing bridge. Dr. Edward Randall, vice-chairman of the Board of Regents of the University of Texas, introduced the speakers.

The session was opened by Mr. C. J. Stilwell, president of the Warner and Swasey Company, who described the activities of his firm in the production of large telescopes and who formally turned over the keys of the dome to Dr. Otto Struve, director of the McDonald and Yerkes Observatories.

In accepting the observatory from the Warner and Swasey Company Dr. Struve spoke as follows:

The purpose of this observatory, in the words of the man whose name it bears, is "the study and promotion of the study of astronomical science." To promote the study of astronomical science means to discover the fundamental laws of nature which govern the structure of the material universe and the changes within it. It means that astronomers must not be passive observers of strange and unexplained phenomena in the cosmos but must be active and intelligent explorers of the vast unknown.

Mr. Stilwell, when I recommended in 1933 to the Board of Regents of the University of Texas that the contract for this observatory be awarded to the Warner and Swasey Company, I knew that your distinguished director of engineering, the late Mr. E. P. Burrell, would be able to meet the exacting specifications which our committee of astronomers had prepared. The telescope was not intended to be just one more expensive gadget to be discarded, ultimately, in the graveyard of scientific instruments. It was to produce answers to a number of specific questions. If it succeeds in this task it will have served its purpose. If it does not succeed, we shall be obliged to regard it as an expensive failure.

There is a story connected with the first attempt to anneal the great mirror disk, after it had been successfully cast at the Corning Glass Works on the last day of 1933. The glass was slightly checked in several places when the annealing oven was removed several months later, and the Corning experts, Dr. Hostetter and Dr. McCauley, immediately offered to melt the glass and to anneal it a second time. During this process of melting, the liquid glass pressed against the firebricks, of which the mold was constructed, and pushed them slightly apart—with the result that we finally got a disk of 82½ inches instead of the contracted disk of 80 inches! I do not guarantee the absolute correctness of this story, but we did get, by some stretching, an 82½-inch disk.

Unfortunately, this is all the stretching our mirror, or for that matter, the truth, will stand. The 82-inch is not a particularly large mirror, and some of our good friends are wasting their time in trying to prove that it will be just as powerful or just as efficient or, anyway, just as good as the Mount Wilson 100-inch. It will be nothing of the sort—as simple geometrical considerations will convince you. I wish we could do some more "stretching," but not even an expert in relativity could stretch the 82-inch mirror to measure 100 inches or to make the half-million dollars available for this project pay for a two-million dollar telescope.

If we can not excel in size we must excel in efficiency. Aperture is important; for some problems it is all-important. Such problems are not within the scope of our observatory. We shall not attempt to extend the geometrical boundaries of the universe of galaxies; this task is taken care of by Dr. Hubble at Mount Wilson. Nor shall we attempt to photograph stars within our own galaxy which are fainter than any hitherto recorded. Dr. Baade is engaged in this type of work with the 100-inch.

What we propose to do is to study intensively the relatively bright stars of our galaxy—as individuals and not only as statistical material. We want to know why it is that all matter in the world is segregated essentially in two forms—stars and nebulae. Why are there no stars which exceed in mass a few hundred times the mass of the sun? Why is it that nearly all stars and nebulae consist of the same chemical elements in roughly the same relative proportions as we find them in the sun? Where and how do the stars generate their stupendous energies of light and heat, and what is the ultimate fate of their radiation?

To answer these and many other similar questions we have made this telescope as efficient and as powerful as we know how for studying the spectra and the brightnesses of the stars and nebulae. We decided to make the telescope relatively short—only 27 feet in focus—so that the images of the stars would be small, even when the air outside is not quiescent. We even built a special spectrograph for the prime focus which effectively converts the telescope from an f/4 instrument to an f/2 instrument. We did this at a sacrifice in limiting faintness of the stars we can observe because we wanted to photograph rapidly hundreds of stars on one plate, instead of spending hours on every single object. There are a billion stars or more, which have never even been looked at and which this telescope will be capable of analyzing and classifying.

We wanted to get a mirror which would be perfectly free of all distortion when used visually or photographically. Corning supplied us with a Pyrex disk which changes little with temperature, and Mr. C. A. R. Lundin has put on it a figure so close to the true mathematical ideal that our experts assure us we have the finest astronomical mirror ever made.

The spectrographic requirements have been constantly in the foreground during the design of the telescope. That we have succeeded in our aim is amply demonstrated by the work of my colleague, Professor Kuiper, during the past six weeks. He has secured some 600 spectrograms of stars never before examined by any astronomer, and has added several brilliant discoveries to the list of his former achievements.

We are indebted to many friends and scientific colleagues for assistance in this project. Perhaps one of the most important features of the 82-inch is the Coudé arrangement for photographing stellar spectra with large prisms or gratings. I need not tell you that this idea was first successfully developed by Dr. Adams at Mount Wilson. We owe another important idea to Dr. Curtis, of Michigan. It was at his enthusiastic insistence that the prime focus and not the Newtonian focus should be used that we scrapped some of our plans—already partly executed—and built a large camera for the prime focus. The telescope drive originated at the McMath Observatory, and to Mr. Robert R. McMath and his collaborators we are deeply indebted for the great help which they gave us when we were designing our drive. My colleagues agree with me that this drive is practically perfect.

It would take too long to even briefly mention all those who have contributed to the success of the McDonald Observatory project. Many of them are here this afternoon.

One hundred years ago—in 1839—two of the world's greatest observatories were opened for research: the Harvard Observatory at Cambridge, Mass., and the Pulkovo Observatory near Leningrad (then Saint

Petersburg), Russia. We are fortunate in having with us here the distinguished director of the Harvard Observatory—Dr. Harlow Shapley. The director of the Pulkovo Observatory is not here—he is a recent victim of one of the most cruel dictatorships of all times. The disturbed international and political conditions of the world to-day are not conducive to quiet research. But the two observatories I have just mentioned have weathered many storms. In accepting this magnificent telescope I venture to hope that the McDonald Observatory is destined to weather the storms of the present and of the future and to become one of the great centers of research where the cultural treasures of the world are preserved and enriched.

A message by President Robert M. Hutchins, of the University of Chicago, who was prevented by illness from attending the dedication, was read by Dean Henry G. Gale, of the Division of the Physical Sciences of the University of Chicago:

This is a great occasion for science and for education. The scientific implications are clear enough. The educational implications are not so obvious, but they are just as important. Two universities are about to demonstrate the value of cooperation on a large scale. We have usually denied the possibility of cooperation. The experience of Texas and Chicago since this observatory was started shows that it is possible and even pleasant. Ever since President Benedict and I first talked about astronomy, the University of Chicago has enjoyed the most cordial relations with the University of Texas. In view of the distance that has separated us and the difficulties inherent in the early days of so vast a project, we can safely say that if we have got along up to now, we shall get along in the future. It is only fair to add that our task has been made easy by the confidence both institutions have had in the distinguished director of the observatory, Professor Struve. Without his unusual combination of energy, tact and scientific knowledge this gathering could not have been held to-day and might never have been held at all. On behalf of the University of Chicago, its faculty, students and trustees, I send the heartiest greetings to the University of Texas and the assembled guests of the observatory. This day will go down in history as one of the brightest in the annals of science and of the universities in America.

Major J. R. Parten, chairman of the Board of Regents of the University of Texas, then spoke for the university:

This is a happy day for Texas. On this day a dream which Texas has long been sharing with its friend and neighbor, Illinois, comes into reality. Texas in general, and the university in particular, can at last call the plant of a modern, powerful observatory their own.

William Johnson McDonald and Harry Yandell Benedict knew and loved the stars. . . . It is because of these two men that the observatory came into being, and that we have reason to be gathered here to-day. In accepting this immensely valuable laboratory for the university we feel that we stand in the light of a day the brightness of which will not soon dim. It is a day made bright by the presence of top-ranking scientists and leading educators, and a day made brighter still by the cherished memory of the two far-seeing Texans who made its sun rise. William Johnson McDonald provided the observatory in quantity of physical plant. Harry Yandell Benedict provided, by his planning and collaboration, the observatory in quality of structure and staff. . . . Our interim president, Mr. John William Calhoun, in 1924, two years before the McDonald bequest became known, put into a statement his own opinions, which were almost precisely those of his predecessor. He wrote: "Among one of the pressing needs of the University of Texas is an astronomical observatory. When the university opened in 1883, it was planned to add astronomy to the curriculum at an early date, but no courses in astronomy were given until 1899; and there is at the present time not even a student observatory on the campus—much less a research observatory with a large telescope such as are possessed by the Universities of California, Wisconsin and Chicago." Dr. Benedict and Mr. Calhoun worked happily with Dr. Hutchins and Dr. Struve to form a basis for the construction and joint operation of the observatory. Texas could by no means have supplied a staff, even had the bequest been greater, to equal that under the present arrangement. The university feels that it is honored and has benefited immeasurably by this association with the University of Chicago. With the staff of the Warner and Swasey Company, the builders of the plant, the University of Texas has enjoyed a most pleasant and satisfactory relationship throughout the performance of the task of design and construction. It is, therefore, a matter of the greatest satisfaction and an occasion of sincerest felicity that the Board of Regents makes for the University of Texas acceptance of the McDonald Observatory.

Dr. J. S. Plaskett, director emeritus of the Dominion Astrophysical Observatory at Victoria, B. C., described the principal features of the new mirror:

The important element of the optical equipment of the McDonald Observatory, which has just been accepted by the director and the chairman of the Board of Regents, is the main concave parabolic mirror having a diameter of 82 inches, a thickness of 12 inches and a focal length of 320 inches. While the telescope can and will be used with the principal mirror only, it should be stated for the benefit of non-astronomical listeners that the usefulness of the telescope would be seriously limited if auxiliary smaller mirrors, generally called Cassegrains, were not also available.

The purpose of the Cassegrain mirror is to increase the equivalent focal length of the telescope, and consequently the magnifying power, without increasing the length of the telescope tube. Such an increase would entail a large increase in the dimensions of the telescope and the size of the dome and would enormously increase the cost of the observatory. The surface of the Cassegrain mirror is convex of hyperbolic form and it is inserted, about 7 feet below the focus, in the converging cone of star light from the 82-inch mirror. The cone of light is hence made less converging and is reflected back towards the main mirror, in the most frequently used form passing through the central hole and forming an image of the star about a foot below the mirror cell. The Cassegrain mirror works on a similar principle to the rear negative element of a telephoto camera lens, which gives an enlarged image without increase of camera length.

This particular low power Cassegrain mirror, which is 28 inches in diameter, is attached to the central focussing sleeve at the upper end of the telescope tube and increases the equivalent focal length to 92 feet and the magnification 3.5 times. The focus, a foot below the mirror cell, is in the most convenient observing position and can be easily reached from the elevating platform in any position of the telescope. The star images can be observed visually, focussed on a photographic plate or on the slit of a spectrograph. It seems probable that the telescope will be used in this form for more than half the observing time.

The second high power Cassegrain mirror is 21 inches in diameter, is attached in the same position and increases the equivalent focal length to 155 feet and the magnification 5.8 times. The light from this Cassegrain mirror falls upon a plane mirror inclined at 45 degrees, which sends the beam centrally along the declination axis to the center of the polar axis. Here a second plane mirror, also inclined 45 degrees, sends the beam down the hollow polar axis forming the star image below the south end of the axis in a temperature controlled room where a powerful stationary spectrograph can obtain high dispersion spectra of the brighter stars. This is commonly called the Coudé form and the McDonald telescope is the first of this type of mounting with the tube at the side of the polar axis to be adapted for Coudé observations.

These different forms of the telescope all depend on the quality of the fundamental optical surface, the 82-inch parabolic mirror and, if it is inferior, only poor images can be obtained with any form of the telescope no matter how good the Cassegrain mirrors may be. Hence we come to consider the specified subject of these remarks—"Some Features of the New Mirror."

Practically every one knows in these days of automobiles that the penetrating parallel beam from the headlights is produced by a parabolic reflector with the light in the focus. Conversely a parallel beam falling on a parabolic reflector will make a bright spot or image at the focus and this is what occurs in a reflecting telescope when star light shines on the mirror. Although the star can not be less than twenty-five thousand billion miles distant, a figure readily appreciated in these days of swollen national debts, and may be a million miles in diameter, the beam of light falling on the mirror is so nearly parallel that no instrument however sensitive could detect any lack of parallelism.

This parallel beam of star light is reflected back from the mirror surface in a converging pencil to a focus at the top of the tube 320 inches above the mirror and forms there an image of the star. If light behaved as if it were shot off from the star as infinitely small particles in straight lines and if the mirror were perfect and the air perfectly steady, there would be a very minute circular image of the star one one hundred thousandth of an inch in diameter, quite invisible as a sensible disc of light even with the highest power eyepiece that could be used. Whatever the nature of light, and physicists are by no means so positive about it as they were thirty or forty years ago, it is certainly not transmitted according to simple geometrical rules. For this purpose, the formation of images by lenses or mirrors, light behaves as if it were transmitted by wave motion. The parallel pencil of light from the star in the case of a mirror is reflected back in a converging pencil but is also diffracted by the edge of the mirror cell forming a diffraction pattern at the focus. This pattern consists of a bright central disc surrounded by a series of bright and dark rings, although 97 per cent. of the light is concentrated in the central disc. This is sometimes called the spurious disc, as it is not the image of the star but the pattern produced at the image of a point source by the manner in which the light is transmitted.

The size of this diffraction disc depends upon the aperture and focal length of the objective and on the wave-length or color of the light and for visual light and the 82-inch mirror is slightly greater than one five thousandth of an inch, twenty times larger than the geometrical image. It is the size of this spurious disc which limits the resolving power of telescopes, as the images of a double star must be separated by the radius of the spurious disc before one can be sure of duplicity. It will be of interest to compute geometrically, without reference to wave theory or diffraction, the optical properties of the 82-inch mirror, and to compare the size of the geometrical image with the diffraction disc.

The quantitative tests were made in the optical shop of the Warner and Swasey Company under practically constant temperature conditions and consisted of measures, by means of an artificial star and knife edge, of the radius of curvature of 12 zones, 2½ inches apart, across the usable surface of the mirror. There were 22 individual measures of each of the 12 radii, 11 each by Mr. Lundin and myself, the probable error of the mean being about one thousandth of an inch for the inner zones and only half that for the more convergent outer zones.

A comparison of the measured radii with those computed theoretically from the properties of the parabola showed remarkably small deviations. Translated into departures of the foci of the zones from the mean focus of the 82-inch mirror, the average departure is only one thousandth of an inch, the maximum amount for an inner zone where the effect on the size of the image would be small is only five thousandths of an inch. There is a relatively simple method for changing these small deviations from the focus into departures of the surface of the finished mirror from the true parabolic curve. No part of the 82-inch mirror, nearly 5,000 square inches of glass, is so much as one millionth of an inch, seven tenths of one millionth, to be exact, from the true theoretical form. This is about one thirtieth of a wave-length of visual light, an indication of the perfection of the optical surface. It is usually considered that a deviation of the wave front of a quarter wave, and hence after the reflection a departure of the mirror surface of an eighth wave should give excellent definition. As the departure of the actual surface is only one fourth the allowable amount it should and does give superb definition.

The quality of the 82-inch mirror may be estimated from a different angle, the diameter of the star image geometrically computed from the measured deviations from the focus. Allowing for the outer zones sending more light to the image, the weighted mean diameter of the geometrical image is less than one six thousandth of an inch, 30 per cent. smaller than the spurious diffraction disc, and hence the aberrations will not enlarge the theoretical image. Further, the specifications called for an image not larger than 0.05 mm, two one thousandths of an inch, while the actual mean diameter is only one twelfth this limit. The diameter of a star image photographed with the 82-inch mirror under only average seeing conditions is 0.05 mm, 1.3 seconds of arc, which will undoubtedly be reduced to 1 second or smaller in good seeing conditions. Obviously the dancing about and spreading out of such a large diffusion disc as 0.05 mm would have markedly increased the photographic image and there can be no doubt that the superb quality of the 82-inch mirror will be of enormous advantage, enabling much fainter stars to be photographed and markedly shortening the exposures required for stellar spectra.

Finally, it will be of interest to make numerical comparisons of the magnitude of the aberrations of the 82-inch mirror with those of the Victoria, Delaware and Toronto telescopes, the only large reflectors whose aberrations have been published. The optical quality is expressed by the smallness of the Hartmann criterion "T," which is simply the mean diameter of the confusion circle in terms of the one hundred thousandth of the focal length. In the McDonald mirror "T" is 0.05 or the confusion circle is only one two millionth of the focal length. The criterion "T," the mean diameter of the geometrical image and the magnitude of the aberrations are 2½ times larger in the Victoria mirror, 3 times larger in the Delaware mirror, and 4 times larger in the Toronto mirror. The Cassegrain mirrors of the McDonald telescope have, I believe, an even greater margin of superiority over the others, and are of superfine quality, the photographic images in average seeing being only increased from 1.3 to 1.5 seconds of arc by the addition of a Cassegrain mirror.

There can be no question of the superb quality of the optical equipment of the McDonald Observatory, nor of the accuracy and great convenience in operation of the mounting of the telescope. The University of Texas and the director and staff of the observatory are very fortunate in possessing such unequalled facilities for extending our knowledge of the universe. They were also very fortunate in having a firm like the Warner and Swasey Company undertake the construction of the telescope and observatory building. No other firm has the facilities to make such an instrument, and I know of no other firm who would persevere in the determination to make this the best and most complete telescope possible without regard to the cost. Tribute should be specially paid, in this description of the optical parts, to the remarkable skill of Mr. C. A. R. Lundin, among the foremost of living opticians, who is in charge of the optical department of the company. It was his skill and experience in optical work and his determination to persevere in the figuring until even his exacting standards were fulfilled that was mainly responsible for the magnificent quality of the optical surfaces.

Professor Arthur H. Compton, of the University of Chicago, spoke on "The First of the Sciences," and outlined the close relation between astronomy and physics. This stirring address will doubtless be published elsewhere.

In conclusion, Dr. Homer P. Rainey, president-elect of the University of Texas, spoke as follows:

The opening of this observatory is an event of great significance to the scientific world, and one of just pride for the people of Texas. For astronomers it is an enlargement and a refinement of the instruments of their craft; it opens new possibilities of extending their chart and knowledge of limitless space. For the University of Texas it is another symbol of the rise of the university to a place of prominence in the world of science.

To the appreciation of one man for the glory of the starry universe in which he lived we are indebted for this magnificent instrument. W. J. McDonald, from his youth, had a profound interest in the wonders of nature which he observed round about him. Although we are told that he had a lively and intelligent interest in animal life, he was especially engrossed in botany and astronomy, and as time went on his love for astronomy overshadowed his other scientific interest. His study of the heavens became so consuming that he left all the accumulations of his life's work for the building and equipping of an astronomical observatory. Mr. McDonald wanted it to be an instrument of such size that it would enable astronomers to peer farther into the universe than man had ever been able to do before.

He once humorously remarked to his Negro barber that some day a telescope would be constructed that would enable an astronomer to see the gold-paved streets of the New Jerusalem. While this telescope which he has made possible can not be expected to reveal to us a celestial city with streets of gold and gates of pearl, it will undoubtedly bring within our vision the vastness and glory of a universe yet unknown that will be more inspiring than that one seen by the disciple on the Isle of Patmos. They very reality of the universe which this instrument will reveal will be far more liberating to the human mind and spirit than the mere fruits of imagination, however inspiring they may have been.

Man's knowledge of the stars has always been a central feature of his poetry and his religion. A contemplation of them has always had what Robert Louis Stevenson called "a serene and gladsome influence on the mind." "The greater part of poetry," he said, "is about the stars; and very justly, for they are themselves the most classical of poets." From time immemorial the stars have had a fascination for man's mind far greater, perhaps, than any other part of the universe. Man's thoughts are never so lofty and pure as when he is in some quiet and serene place gazing into the heavens and listening to "the music of the spheres."

Mr. McDonald, therefore, has made far more than a contribution to the advancement of science. He has made possible the enlargement and the uplifting of the soul of man, and this is a gift that surpasses all others.

In our rejoicing over this munificent gift from Mr. McDonald we should not fail to recognize also the splendid part which former President H. Y. Benedict had in the erection of this observatory. He was himself an astronomer and he understood the requirements of an astronomical observatory. He had an exceptional grasp of the entire situation, and it is because of his understanding that the observatory is located in the most advantageous spot in Texas.

There is perhaps no better place in the entire country for an observatory. Texas has long been famed as a land "where the skies are not cloudy all day," and in this particular region there are more cloudless days than in almost any other place. Furthermore, the atmosphere in this region is as clear as any that can be found, which will be a marked advantage in observations. There is also another favorable feature of this "Olympian station." It is far from even "the whispering rumor of a train" or other disturbances, and where, in the evening, the world falls into a dead silence conducive to observation, reflection and contemplation. All these factors combine to make this a most fortunate location for the observatory.

Another unusual feature of this entire enterprise is the fact that for thirty years it is to be operated cooperatively by the University of Texas and the University of Chicago. President Hutchins, who conceived this cooperative relationship, has already spoken of this situation. So far as I know, this relationship is unique and is, I believe, a very fortunate one. This sort of cooperation suggests other similar possibilities. It happened in this case that the University of Texas had the funds for an observatory but did not possess a faculty in astronomy, and a telescope is of very little use without astronomers to operate it. On the other hand, the University of Chicago had an outstanding faculty, but was in need of more and better equipment for observation. Speaking for the University of Texas, I can assure President Hutchins and the trustees of the University of Chicago that we are delighted with this arrangement, and we anticipate many fine values to accrue from it over and above the magnificent scientific research which will be done here. We pledge the University of Chicago our complete cooperation to the end that the finest possible results may be realized through this joint enterprise.

We are here to dedicate this observatory to the most ancient and purest of all the sciences. In doing so, may I express the hope that this observatory will stand as an enduring symbol of the insatiable desire of man to discover the secrets of the universe, and that it may also stand as a symbol of the freedom of man's mind to explore the boundless areas of truth without any restrictions whatsoever.

To these ideals I dedicate the McDonald Observatory in the name of the University of Texas, and now declare it open for research.

The dedication was followed by a symposium, sponsored by the Warner and Swasey Company, on "Galactic and Extragalactic Structure," the program of which was given in SCIENCE for March 3, 1939. The majority of the symposium papers will be published in the *Astrophysical Journal.*

BIOPHYSICS AND HYDRAULIC ENGINEERING

By Dr. J. F. HERRICK

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How many hydraulic engineers have had their attention attracted to the circulatory system of man and animals? Perhaps it is the most ingenious hydraulic engineering feat in nature. Few investigators have taken a broad glance at the circulatory system from an engineer's point of view.

The purpose of the present paper is to describe some fundamental problems which confront the biophysicist who is interested in the circulatory system. These problems require a thorough understanding of applied fluid mechanics. The hydraulic engineer is better prepared than the average biophysicist to attack such problems.

In the blood vascular system we have a circulatory system in which the average pressure is maintained at a relatively constant value unless an emergency alters it, whereupon a mechanism is called into action which promptly restores or attempts to restore normal conditions. When certain defects develop, the normal pressure becomes inadequate for performing the necessary functions. Under these conditions the system operates at a higher pressure, thus introducing its compensatory mechanisms. The various mechanisms whereby the circulatory system accomplishes its functions of (1) supplying nutritive materials to different parts of the body, (2) eliminating the waste products of catabolism, (3) regulating the pressure, (4) regulating the temperature and (5) distributing hormones and various chemicals to their proper depots, would fascinate any hydraulic engineer.

The particular problems which confront us at the moment and which I wish to describe have to do with pressure and with flow and will be treated separately.

PRESSURE

Methods of measurement. The ideal method for measuring blood pressure is still lacking. True enough, the measurement of the pressure is an everyday affair. The universally used method is an indirect one where pressure is applied in order to cause a complete collapse of the blood vessel. If arterial pressure is being observed, both systolic and diastolic pressures are recorded. These pressures are those which occur simultaneously with certain arbitrary sounds heard over the given artery by means of a stethoscope on releasing the collapsed vessel. I shall not take time to describe the details of the apparatus and the technique used in this (auscultatory) method. The standard method which is used experimentally consists in cannulation of a given blood vessel and proper communication with a suitable manometer.

The ideal method would be one which permits continuous recording of blood pressure—an automatic method, so to speak. The indirect method obviously does not permit continuous observation. The direct method makes constant recording impossible because there is no anticoagulant which keeps blood from clotting for an indefinite period. In addition, the isolation and cannulation required also limit the time of recording.

One might imagine a possible relation between the pressure on the wall of a partially closed blood vessel and the true pressure of the contained blood. If such a relation could be found to be consistent, the pressure on the wall of the vessel might be recorded by using the principle of piezoelectricity. Such a method as this would permit continuous observation of blood pressure.

To put the problem in question form: how would you measure the pressure of a coagulable fluid circulating in a closed elastic system without either direct communication with the fluid or completely collapsing the elastic "pipe"?

Differential pressure. Owing to the action of the pump in this circulatory system the pressure varies throughout the cycle of the pump (cardiac cycle). When the pump is contracting, the pressure in the system is maximal and is named systolic pressure. When the pump has finished its contraction and is temporarily in a state of rest, the pressure in the system is minimal and is called diastolic pressure. One may also observe the average pressure throughout the cardiac cycle. As in other hydraulic systems there is a gradual decrease in the average pressure throughout the system from the output to the input sides of the pump. The term pressure-gradient characterizes this well-known variation. However, if one considers the systolic pressure only, an interesting phenomenon presents itself—the systolic pressure in the leg artery (femoral artery) is about 30 to 50 mm of mercury higher than that in the neck artery (common carotid artery) in spite of the fact that the leg artery is much