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September 1951

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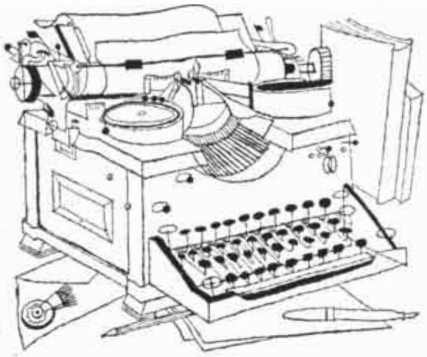
GENERAL ELECTRIC

LETTERS



Sirs:

I enjoyed the article entitled "The Theory of Numbers" in your July issue, particularly the passage that dealt with the celebrated problem of the sailors and the coconuts. However, the author has only three sailors in his problem, whereas I have heard the problem stated with five. Is there a similar solution for the problem with five sailors?

WILLIAM R. JORGENSEN

New York, N. Y.

Sirs:

The interesting article in your July issue, "The Theory of Numbers," has revived my interest in a problem told me by a calculus teacher at the University of California a while back. I have read several books on mathematical problems but found myself looking in vain until reading your article. I wonder if you can help me, either with the answer or a suggestion as to how to solve the problem.

The problem is the same as yours of the three sailors and the coconuts, except that there are *five* sailors. I replaced n in your general formula by five and obtained this equation: $1024x-3125y=8404$. Knowing that y would be the smaller value, I assigned values to it, and further simplified the problem by discovering that y must end in a zero. With large graph paper I proceeded to plot the above linear equation, assigning values to y of 10, 20, 30, 40 . . . and trying only values of 6, 11, 16, 21 where the curve crossed *near* to values of x. . . . Using this method I have so far eliminated values of y to $y=480$. This may go on for a long time! Isn't there some mathematical way of finding the smallest values of x and y so that x is divisible by five with a remainder of one and y exactly divisible by five?

I would appreciate it very much if you could help me in any way at all.

WILLIAM A. BARNETT

Berkeley, Calif.

Sirs:

The following solution of the equation $1024x-3125y=8404$ (the coconut problem with five sailors) serves to illustrate a general method of solving a Diophantine equation in two unknowns. The equation may be written

$$x=\frac{3125y+8404}{1024}.$$

Performing the indicated division we have

$$x=3\frac{53}{1024}y+8\frac{212}{1024},$$

or

$$x=3y+8+\frac{53y+212}{1024}.$$

The fractional expression on the right must be an integer, since *x*, *3y* and *8* are integers. Thus

$$\frac{53y+212}{1024}=a$$

(where *a* is an integer), or

$$y=\frac{1024a-212}{53}.$$

This becomes

$$y=19\frac{17}{53}a-4$$

or

$$y=19a-4+\frac{17a}{53}.$$

Again, the fractional expression is an integer: $17a/53=b$. Then

$$a=53b/17=3b+2b/17;$$

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$$b = 8c + c/2;$$
$$c = 2d.$$

We now have an integral expression for *c* and may solve for *b* in terms of *d* ($b=17d$), for *a* in terms of *d* ($a=53d$), and so on for *x* and *y*, finding that $x=3125d-4$, $y=1024d-4$. Thus we have integral expressions for *x* and *y* in terms of a parameter, *d*. Any integral value given *d* will produce a solution of the original Diophantine equation. In fact, this is the most general solution of the equation. To find the least number of coconuts that five sailors might have gathered we need only find that value of *d* which will make *x* as small as possible while keeping *y* positive. Thus $d=1$ gives $x=3121$, $y=1020$.

PAUL S. HERWITZ

Chapel Hill, N. C.

Sirs:

The interesting article by L. V. Heilbrunn, "Calcium and Life," in your June issue serves to perpetuate a common fallacy, namely that teeth and bones are not "truly living tissues." Actually research with radiocalcium and other bone-seeking minerals, such as gallium, strontium, arsenic and yttrium, among others, indicates that there is a rapid uptake by bone when these minerals are given by intravenous injection, and that in rats elimination of these minerals from the bones occurs within 10 days. Although in general these elements are deposited primarily in areas of rapid growth, this is not always the case (*e.g.*, plutonium). Singer and Armstrong injected radioactive calcium into adult rats and found that approximately half of the radioactive calcium was lost from the bones of adult rats in 52 days. This is indicative of a high rate of calcium turnover.

These observations are but samples of the many which can be presented to show that bone is a living tissue in dynamic equilibrium with the fluids bathing it. While it is undoubtedly true that the components of bone are exchanged more slowly than those of other tissues, this should not be taken as any indication that bone and teeth are any less "living" than other parts of the body.

FELIX BRONNER

ROBERT S. HARRIS

Nutritional Biochemistry Laboratories
Department of Food Technology
Massachusetts Institute of Technology
Cambridge, Mass.

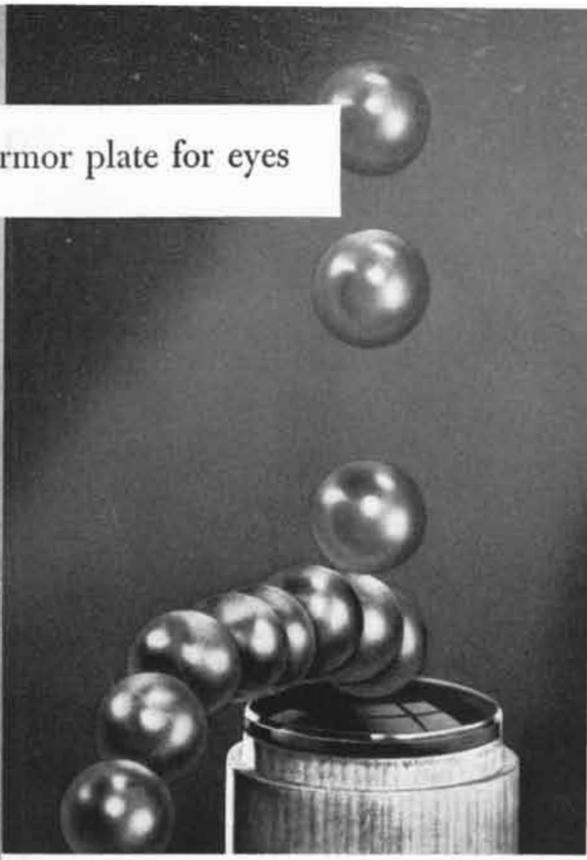
Sirs:

When philosophy beckons to the unsuspecting scientist, wouldn't he be wise to turn his back upon the fair temptress

PROBLEM: A hemoglobin laboratory for use at patient's bedside

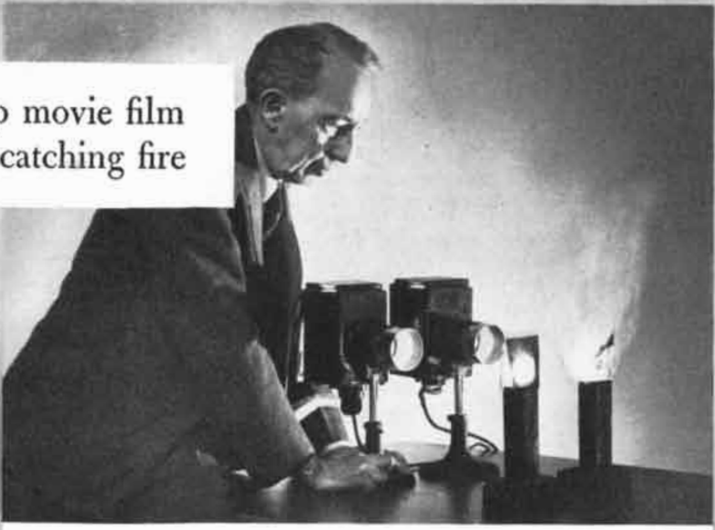
ANSWER: Today, a physician need not send blood samples to a laboratory for hemoglobin analysis and delay diagnosis. Within 3 minutes, he can read the answer in the Hb-Meter. This meter is so fast that a patient's condition can be watched during treatment. Heart of the instrument is an accurately polished glass wedge, graded in color, against which the blood sample can be matched. The Hb-Meter is a creation of American Optical Company.

PROBLEM: Armor plate for eyes



ANSWER: If you dropped steel balls on *your* glasses, they'd shatter in dangerous splinters. AO safety-goggle lenses won't splinter. Scientists at American Optical devised a heat treatment that makes glass many times as strong, eyes safer.

PROBLEM: To keep movie film from catching fire



ANSWER: *Right,* film shielded by ordinary glass catches fire. *Left,* AO heat-absorbing glass prevents fire. This glass, developed for floods and projectors, absorbs 90% of heat from projected light, passes movie-film color in true values. Write us about your development problems. American Optical Company, 12 Vision Park, Southbridge, Mass.

American Optical

in the spirit of Lewis Carroll, who wrote:

And what mean all these mysteries to me
Whose life is full of indices and surds?

$$x^2+7x+53 = \frac{11}{3}$$

It was a statistical philosopher who assured us that a team of monkeys, at typewriters, would eventually reproduce the complete works of Shakespeare. Now, with a verse in the Letters department of your July issue, another one says that everything is statistical, and not the least bit mystical! Most of us mystics feel unable to wait for scientific confirmation by the monkeys. We are likely to suspect the statistophers of having dogmatic faith unless they can give us more evidence. For example, it would help perhaps if they could prove the statistical necessity for a law of probability. By the time the monkeys have written *Hamlet,* perhaps the heads will come up twice as often as the tails. Meantime the undogmatic will continue along as a mystic.

B. G. CHYNOWETH

Berkeley, Calif.

ERRATA

The article entitled "The Fertilization of Flowers," which appeared in the June issue of SCIENTIFIC AMERICAN, contained the following statement: "Corn plants . . . are pollinated primarily by wind but also sometimes by bees." This sentence should read: "Corn plants . . . are visited by pollen-collecting bees, but they are pollinated by the wind."

The same article states that the insects, birds and mammals arrived on the earth at the beginning of the Tertiary Period. Actually these animals appeared before the Tertiary. In that period, however, the birds and mammals became dominant and the long-tongued insects first appeared.

In a caption that accompanies one of the illustrations for the article it is stated that "*Strelitzia* . . . has a landing platform at the right for the sunbird." In the illustration the landing platform is at the left; the structure at the right is the ovary. These errors are the responsibility of the editors and not the author.

In the July issue Paul S. Herwitz, author of the article entitled "The Theory of Numbers," was identified as associate professor of mathematics at the University of Cincinnati. Actually Mr. Herwitz was a graduate assistant at that institution.

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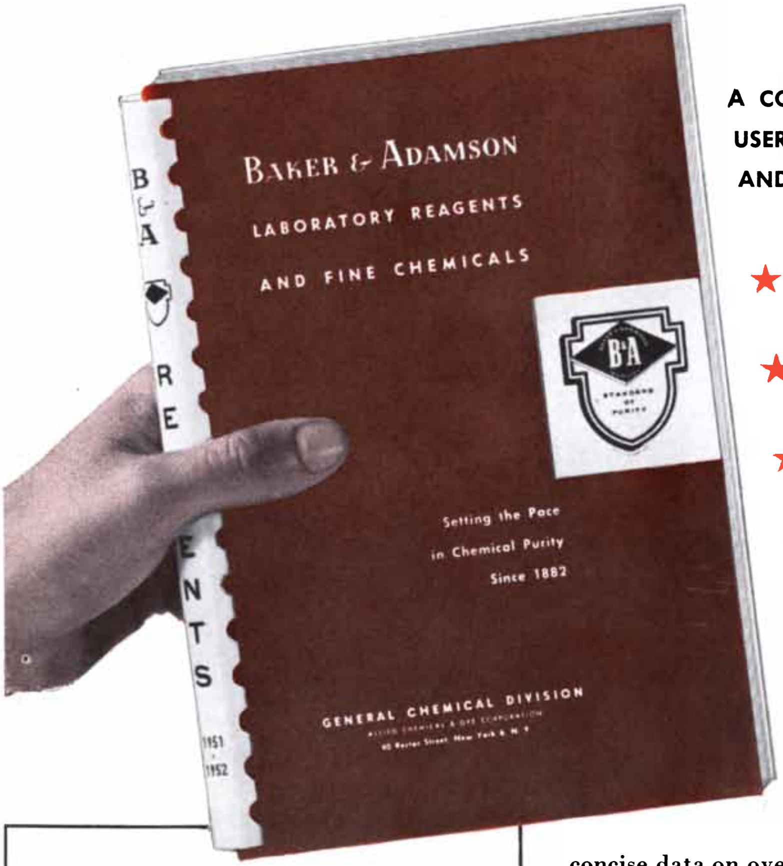

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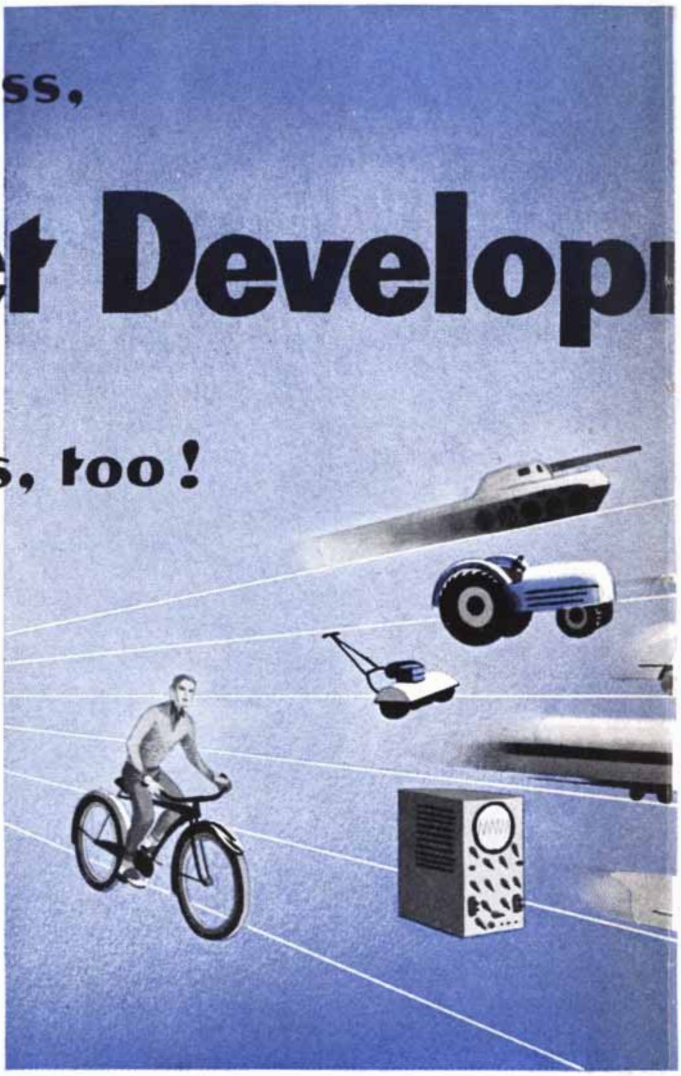

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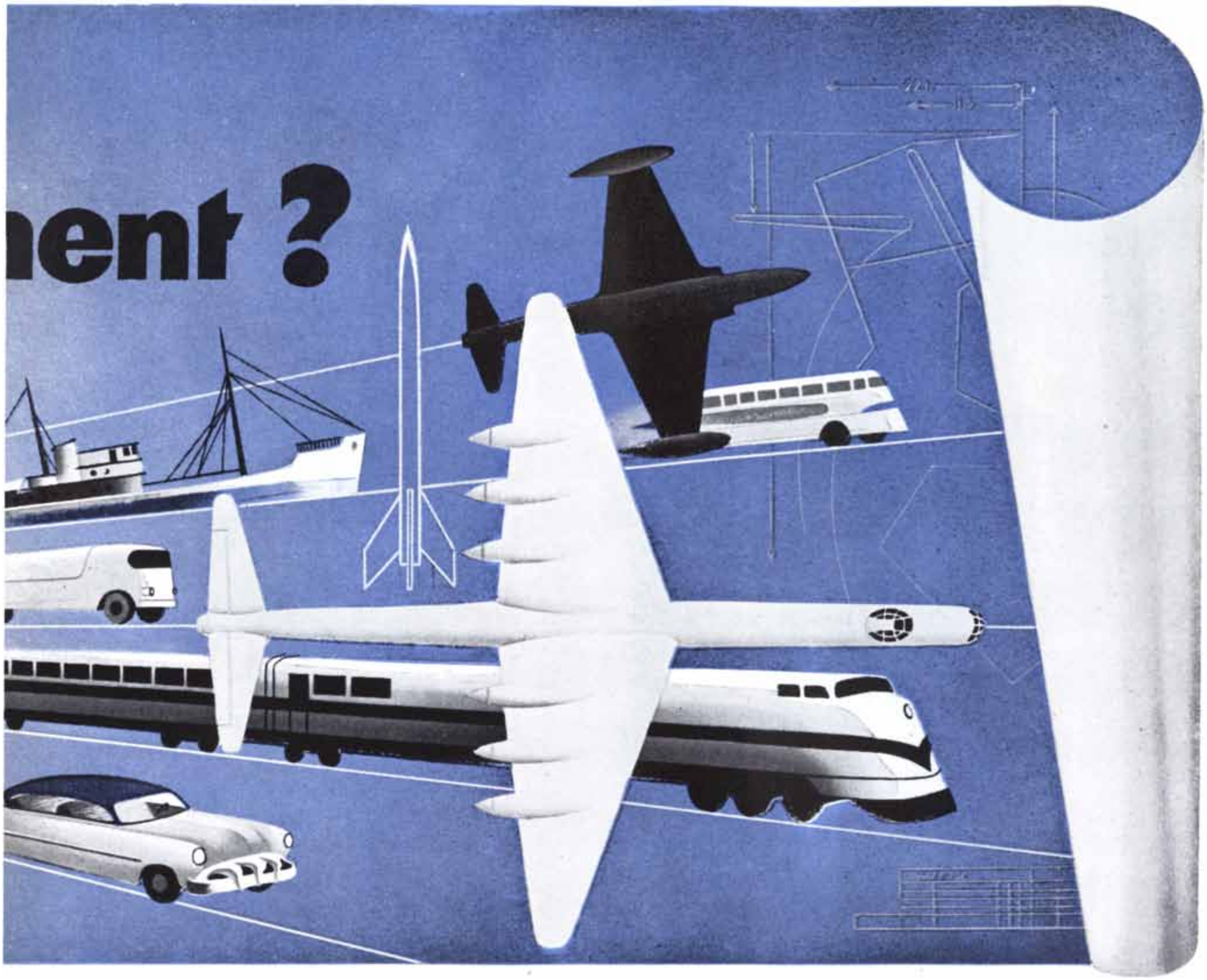

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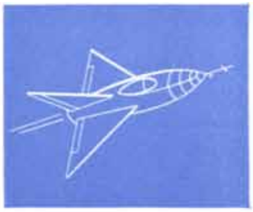

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50 AND 100 YEARS AGO

SEPTEMBER 1901. "Helium and its gaseous companions on the one hand and the radioactive substances on the other are mysteries which have so far completely baffled our chemists. And uranium and thorium, elements with which we once considered ourselves thoroughly familiar, are now to us as curious as if they had been but the discoveries of yesterday. If the eccentricities of uranium, thorium and helium, and the mysteries of Roentgen rays, cannot be adequately accounted for by our existing chemical system, the question arises: Can our system be wrong? Some day a chemist will be found whose mind, broad enough to grasp the scattered facts unearthed in the course of a century of research, will elaborate a chemical system which may prove revolutionary but which will embrace in its comprehensiveness those puzzling gases and radiant substances so utterly inexplicable at present."

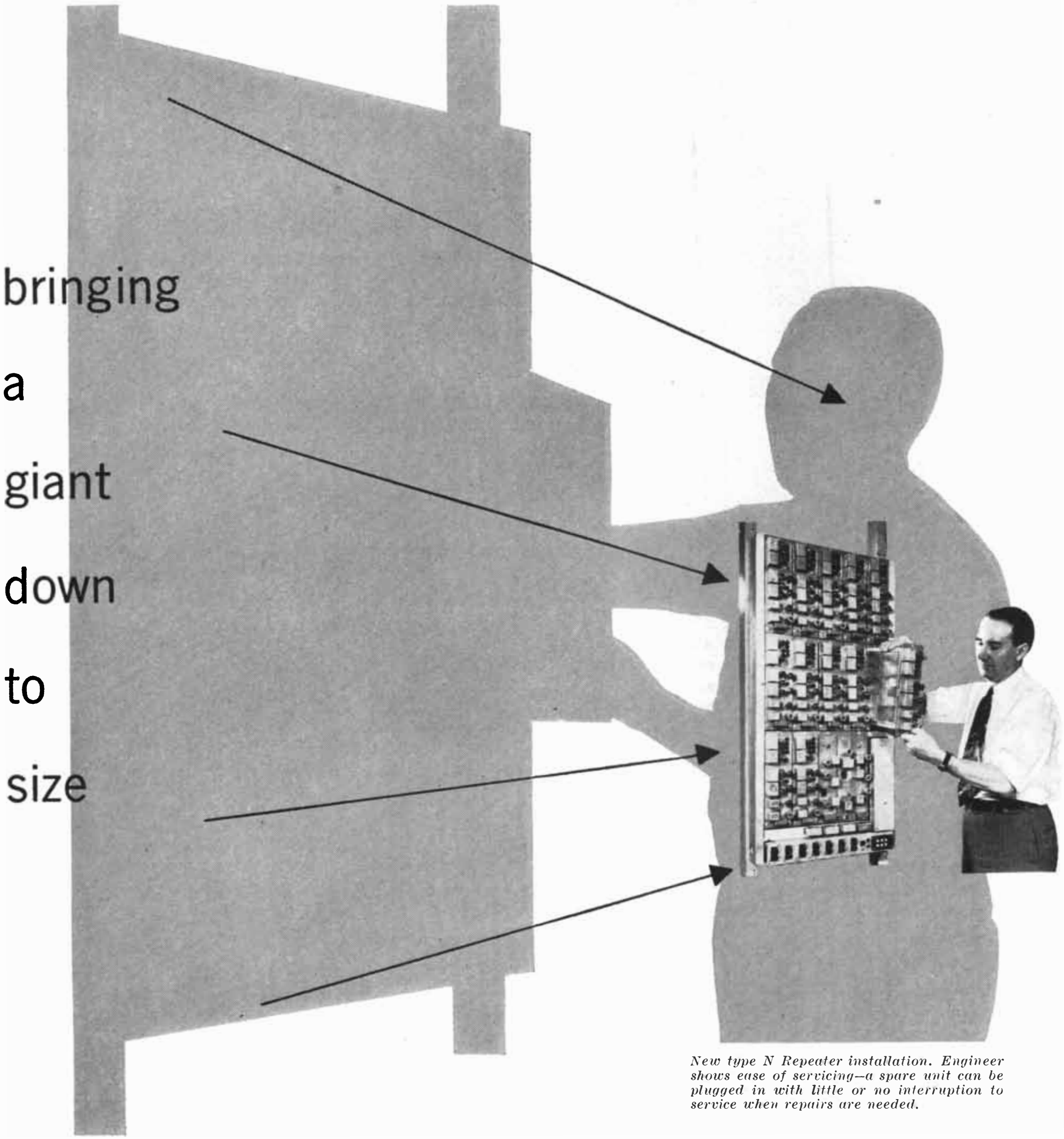
"The fiftieth annual meeting of the American Association for the Advancement of Science was held in Denver from August 24 to 31, under the presidency of Prof. Charles S. Minot, of Harvard University. The meeting was well attended, and about 220 papers having a high order of merit were presented, some of which were of the greatest scientific interest and importance. The cliff dwellers received a large share of the time of the anthropologists on account of the proximity of the ruins and the local interest in the subject. Prof. T. C. Chamberlin, of the University of Chicago, gave the results of many years of patient investigation. He has found that the nebular hypothesis of Laplace and others cannot stand against the arguments arising from the mathematical consideration of the laws of mass and momentum. A new section was organized at this meeting for the study of physiology and experimental medicine under Prof. Cattell, of Columbia University."

"The problem of the past history and future destiny of the solar system has occupied much attention during the century. Helmholtz concludes that if the intensity of radiation has been uniform from the beginning, the present order cannot have existed longer than 22,000,000 years. Others make the period less. Looking into the future, at the end of 5,000,000 years, the sun will have contracted to half its present volume, and at the end of another 5,000,000 years it will be mainly if not entirely solid, and must have ceased to be self-luminous much earlier."

"M. Demarçay, in the course of his spectrum analysis work, claims to have discovered a new element, to which he proposes to give the name of europium."

"H. Becquerel has confirmed, by an unpleasant experience, the fact first noted by Walkoff and Giesel, that the rays of radium have an energetic and peculiar action on the skin. Having carried in his waistcoat pocket for several periods, equal in all to about six hours, a cardboard box enclosing a small sealed tube containing a few decigrammes of intensely active radiferous barium chloride, in ten days' time a red mark corresponding to this tube was apparent on the skin; inflammation followed, the skin peeled off and left a suppurating sore which did not heal for a month. A second burn subsequently appeared in a place corresponding to the opposite corner of the pocket where the tube had been carried on another occasion. P. Curie has had the same experience after exposing his arm for a longer period to a less active specimen. The reddening of the skin at first apparent gradually assumed the character of a burn; after desquamation a persistent suppurating sore was left which was not healed fifty-six days after the exposure. In addition to these severe 'burns' the experimenters find that their hands, exposed to the rays in the course of their investigations, have a tendency to desquamate, the tips of the fingers which have held tubes or capsules containing very active radiferous material often become hard and painful; in one case the inflammation lasted for fifteen days and ended by the loss of the skin; and the painful sensation has not yet disappeared after the lapse of two months."

"The greatest credit is due to that indomitable explorer, Lieutenant Peary, for his latest work in defining the geography of the Arctic regions. Although he has not as yet succeeded in reaching the North Pole, nor, indeed, in traveling as far north as did Nansen and Abruzzi, as a result of his work around the northern coast of Greenland, the geographical boundaries of the great island of the Northern Hemisphere are now defined with scientific accuracy. Thus the explorations of Greenland, which have been in progress now for a thousand years, are



New type N Repeater installation. Engineer shows ease of servicing—a spare unit can be plugged in with little or no interruption to service when repairs are needed.

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Now Bell Laboratories have developed new short-haul carrier, economical down to 25 miles, sending 12 conversations on two pairs of wires in a cable.

Keys to the new system are new circuits, miniature tubes, pocket-size wave filters and Permalloy "wedding ring" transformer cores that will barely slip over a man's finger. New manufacturing processes were developed in co-operation with the Western Electric Company. Components are pressed into a plastic mounting strip with heat, a score at a time, instead of being mounted separately.

With this new carrier system more service can be provided without laying more cables. Tons of copper and lead can be conserved for other uses. It's another example of how science takes a practical turn at Bell Telephone Laboratories, to improve service and to keep its cost down.

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WORKING CONTINUALLY TO KEEP YOUR TELEPHONE SERVICE ONE OF TODAY'S GREATEST VALUES practically completed by Peary's arduous labors and thoroughly scientific methods. Peary has also done great service to Arctic exploration by proving that his theories as to the best method of traveling are correct. He set out on this last trip with the conviction that, if the North Pole is ever to be reached, it must be done with the co-operation of the natives and with the extensive use of dogs and sledges. In his recent work he has given practical proof of the soundness of his theories. Early in the next spring it is his purpose to make a final 'dash for the North Pole' which, if successful, will add greatly to his well-earned fame."

"Experiments have been made at Havana to test whether yellow fever is carried by mosquitoes. Out of eight persons bitten by infected insects three have died, three have the fever and will possibly recover, one is not affected, while as regards the remaining case it is too early to make a diagnosis. The physicians are shocked at the result of the experiments. It was supposed that direct infection from mosquitoes caused only a mild form of the disease, and was a safe means of making the subject immune."

"On the occasion of the three hundredth anniversary of Tycho Brahe's death the Prague Town Council decided to gather together the remains of the celebrated astronomer, which were in the Teyn Church, and bury them anew. Under the guidance of Mr. Herlein this operation was begun. After having lifted the stone block on the monument, a semi-collapsed arch was found, and on removing the stones two mouldering coffins were seen. At about 10 a.m., the lid of the first coffin was removed. It was a surprising sight that met the eye; the body in the coffin was a wonderful likeness of the effigy on the monument. The head was slightly turned to one side, the bones of the face and the peaked Spanish beard being well preserved. That the body was Tycho Brahe's was also seen from the absence of the nose. Tycho had lost this organ in a duel and wore a silver one in its place. Among the rubbish was found a silver wreath."

SEPTEMBER 1851. "It seems scarcely possible for us of the present generation to conceive of the period when the country shall be stripped of its forests. By a few facts some idea may be formed of the rapid destruction of the white pine. At Bangor there are 1,500 sawmills in operation which manufacture 300,000,000 feet of planks, boards, and timber, without making any estimate of shingles and laths. This is the production of one state. In the Western states, vast quantities of timber in trees are annually destroyed in the process of clearing land for cultivation. Our locomotives are destroying

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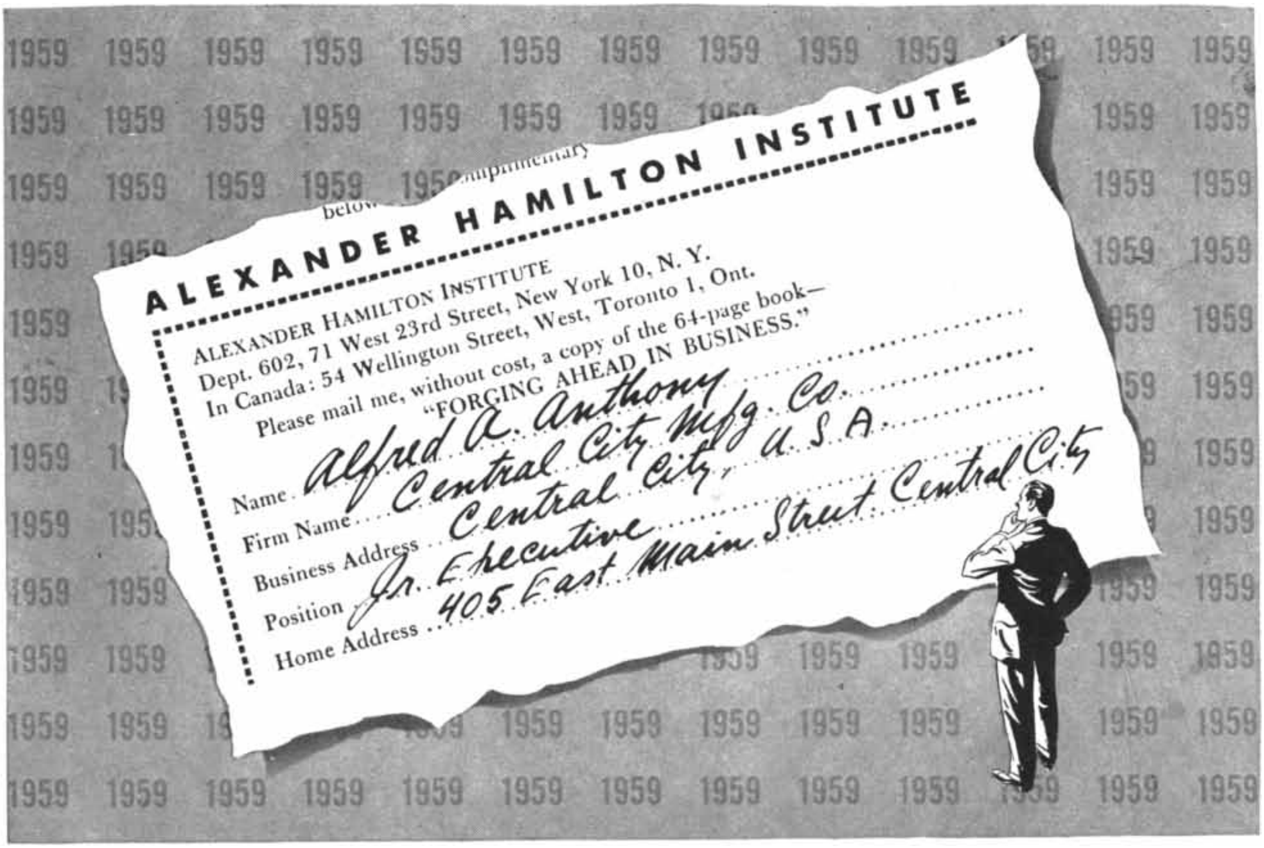

The Years That Might Have Given Them So Much Will Pass On Forever, Casting Back a Look of Scorn

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"Years ago I should have thought about my business future."

"What a world of difference it would have made if I had written this letter ten years ago."

"I put it off—just put it off."

These are the lost and discouraged men who were content to *wait* for success; men who had no definite, well-defined program which would carry them a little closer, each day, to their chosen goal. Delay stamps its footstep on the pages of time and always leaves regret.

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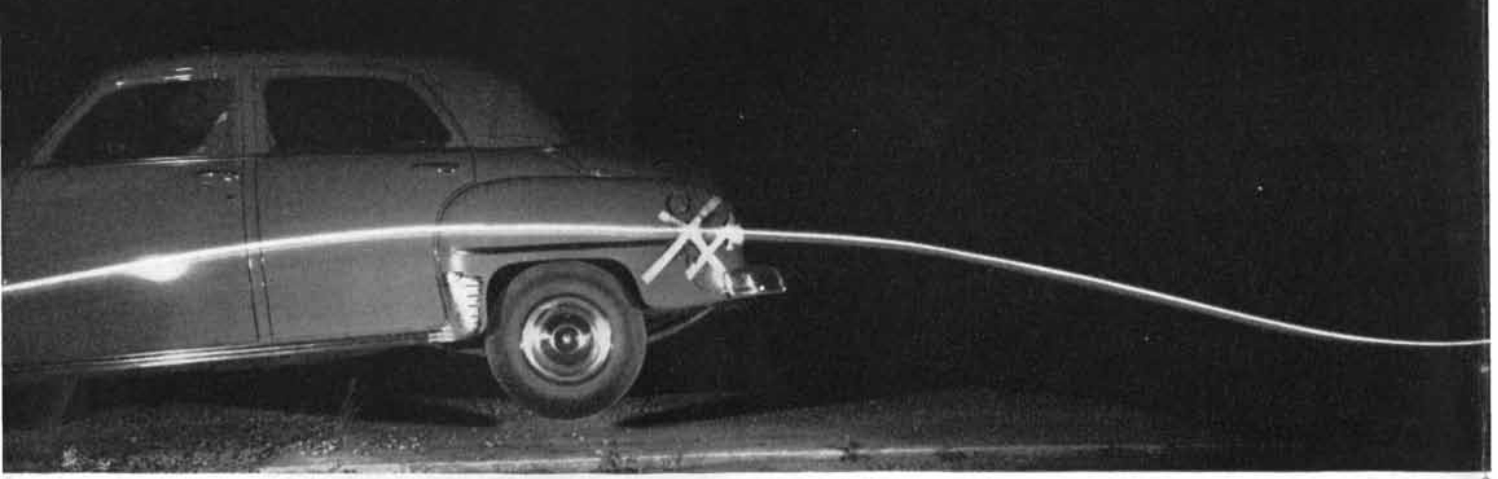
square miles of timber every year, and in many places where stood the forest fifty years ago, a cord of wood cannot be purchased for less than a sum which would purchase six acres of land then. Our farmers do not seem to be making allowance in raising a second growth of timber; a fact very little to their credit, for every farm should be surrounded with a wood belting of good trees, for the sake of shelter from high winds, and for supplying themselves with timber."

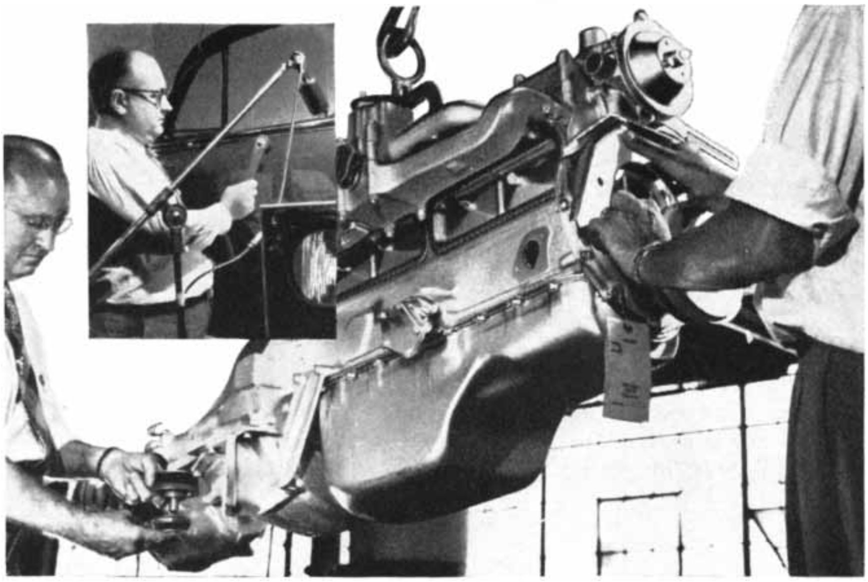
"It has now become very well known that the electric fluid pervades all nature, and that its properties are in many respects analogous to those of light and heat. It is probably identical also with the attraction of gravitation, and some have even supposed that it is one and the same thing with the vital principle. Electricity and magnetism are also one, and the opinion that it is the one universal force, of which all others are merely modifications, is rapidly gaining ground. The velocity with which the electric current travels along metallic wire is prodigious. Further observations may probably show that light and electricity are altogether identical."

"A valuable deposit of iron ore has been found on the north shore of Lake Superior, at Groscap, near the Michipicoten River. Large quantities of iron ore are found in dikes, so near the coast that it can be wheeled on board a vessel. It is said that thousands of tons may be obtained at that place very readily."

"The American Association for the Advancement of Science met yesterday with Professor Louis Agassiz in the chair. The chairman is a foreigner and is the pupil of the celebrated Cuvier. He is allowed to be the first zoologist in the world, and is the author of the glacial theory of geology. He is a splendid looking man, and speaks with a slightly foreign accent. Lieut. Davis presented a very able paper, chiefly relating to the work of Mr. Longstreth, whose computation of the exact period of the recent eclipse surpassed in correctness that of all the European astronomers. Prof. Pierce of Harvard, one of our most eminent philosophers connected with the observatories, congratulated America on this work. Within two years the discoveries of Americans in astronomy have elevated our country very highly in the eyes of the world. A number of papers had no earthly interest whatever. One thing was apparent in reference to many of them, *viz.*, the absence of anything relating to the practical arts—nothing on engineering, nothing about chemistry applied to the everyday arts. Our American Association is yet destitute of a class of members more practically useful than the great majority (not all) which they now have, meaning our engineers and mechanics."



NEW KIND OF SHOCK ABSORBER. Mili's camera caught two cars taking the same tough test bumps at the same speed, with lights attached to trace their line of ride. The 1950 Plymouth in the upper picture has ordinary shock absorbers, the 1951 Plymouth in the lower picture has new Oriflow Shock Absorbers. The startling difference in their rides is the result of a genuinely new shock absorber which makes entirely new use of hydraulic principles to give $2\frac{1}{2}$ times the cushioning effect of previous types. Oriflow Shock Absorbers add new comfort and safety to your ride, prove again that *you get the good new things in Chrysler-built cars.*



STEPS TO A SMOOTHER, QUIETER RIDE. Engineer Carl Redford, left, and an associate point out the secret of Chrysler Corporation's smooth, silent *Floating Power*. You see two of the three thick rubber "sandwiches" that support this powerful De Soto engine at its points of natural balance, high in front, low in back.

(*Inset*) Engineer H. R. Smith "auditions" the door of a Chrysler New Yorker. Laboratory recordings are made of most other car parts, too, to find the most effective sound-insulating materials for Chrysler-built cars. Final selections of fibers, liquids and rubber are made from sensitive recordings of road tests.

WANTED: ORNERY ROADS. Chrysler Corporation test drivers track down the meanest stretches of road they can find to make sure their cars give smoother rides under all conditions. This new Dodge is being paced over a wicked "roller-coaster" road. Pothole roads also help measure riding comfort under extreme conditions, insure smoother performance in all Chrysler-built cars.

CHRYSLER CORPORATION'S

NEW SHOCK ABSORBER HELPS GIVE THE SMOOTHEST, SAFEST RIDE IN AUTOMOTIVE HISTORY

Engineers and test drivers team up to build a new kind of ride into Plymouth, Dodge, De Soto and Chrysler cars

Gjon Mili, famed magazine photographer, turns his talented camera backstage at Chrysler Corporation to picture the story behind the sensational new kind of ride you get in the new Plymouth, Dodge, De Soto and Chrysler cars.

America's cars are vital to her way of life. Here Gjon Mili shows how these cars are made by a company that today is helping to strengthen this nation's security in still another way—by filling important defense assignments.

COMFORT GETS TRIED ON FOR SIZE. Chrysler Corporation car plans are put to many practical tests. Here a Chrysler seat is being checked for comfort and visibility by draftsman L. Buccallato and engineer Vincent Buck. In addition to Chair-Height seats, Chrysler-built cars feature larger windows, slender corner pillars, wider doors, welcoming roominess all around. These are important safety factors, too: a comfortable, relaxed ride is a *safe* ride.

HE TAMES LIVE WEIGHTS. On this rack, suspension engineer R. R. Peterson shows how distribution of weights affects springing action. Oriflow Shock Absorbers are only one of the reasons for the new, smoother, safer ride built into Plymouth, Dodge, De Soto and Chrysler cars. Super-tough springs must pit their strength against the weight of the car and the jolts of the road, must work with shock absorbers to absorb both large and small bumps. In Chrysler Corporation cars, these springing systems are scientifically synchronized to cushion the smoothest automobile ride you have ever had.

CHRYSLER CORPORATION engineers and builds **PLYMOUTH, DODGE, DE SOTO, CHRYSLER CARS & DODGE TRUCKS**

Chrysler Marine & Industrial Engines • **Oilite** Powdered Metal Products • **Mopar** Parts & Accessories • **Airtemp** Heating, Cooling, Refrigeration • **Cycleweld**

THE COVER

The painting on the cover, made by the famous American artist Ben Shahn, symbolizes the subject of this issue of SCIENTIFIC AMERICAN: the human resources of the U. S.

THE ILLUSTRATIONS

Cover by Ben Shahn

The illustration at the opening of each article in this issue is by Bernarda Bryson

Page	Source
30-31	Irving Geis, from data supplied by Frank W. Notestein.
32-33	Irving Geis, from U. S. Bureau of the Census.
34	Irving Geis from *Population Trends in the U. S.*, by Warren S. Thompson and P. K. Whelpton; *Vital Statistics of the U. S., 1948;* data supplied by Frank W. Notestein.
35	Irving Geis, from data supplied by Frank W. Notestein.
38	Eric Mose, from U. S. Bureau of the Census and *Labor Force in the United States, 1890-1960,* by John D. Durand.
39	Eric Mose, from U. S. Department of Labor, Bureau of Labor Statistics.
40	Eric Mose, from U. S. Bureau of the Census.
41	Eric Mose, from U. S. Bureau of the Census and estimates by U. S. Department of Labor, Bureau of Labor Statistics.
44	Sara Love, from "School Population of the Future," by Hope T. Eldridge and J. Williams in *School Life.*
45	Sara Love, from data supplied by Dael Wolfle.
46	Adolph Brotman, from U. S. Office of Education and

(*continued on page 20*)

IDEA-CHEMICALS

. . . from Du Pont Polychemicals Department

HYDROXYACETIC ACID

makes a milder, safer cleanser

In the cleaning of dairy equipment, alkaline detergents were formerly used almost exclusively. But alkalies were not effective in the removal of milkstone, a hard milk residue. This and other problems were solved by the development of a better detergent using Du Pont Hydroxyacetic Acid. Properly formulated, detergents made with Hydroxyacetic Acid remove milkstone and effectively retard bacterial growth on the surfaces of the cans. And they leave no white film, odor, or carry-over of any kind.

Hydroxyacetic Acid's properties make it a valuable chemical for other industries, too—for example, wool dyeing, organic syntheses and metal-finishing operations. And they suggest many new applications. A few possibilities are: as a coagulant for raw latex, an ingredient of soldering flux, and as a reagent for developer solutions in photography.

Your business may find opportunities for profitable future use in Hydroxyacetic Acid . . . or in many of the other Polychemicals products. There are more than 100 of them—organic acids, amides, alcohols, ammonia, esters, resins, solvents, and plastics.

Although demand for many of these products now exceeds supply, we will gladly discuss the availability of experimental quantities for developmental work.

Write for technical booklet on Polychemicals products for your industry

Technical bulletins on Hydroxyacetic Acid and the chemicals and plastics used in your industry are available. Each product bulletin in the booklet presents physical and chemical properties, description, specifications, uses and possible applications, bibliography and other data. Write us on your business letterhead for your copy—and please tell us the name of your industry.

E. I. du Pont de Nemours & Co. (Inc.)
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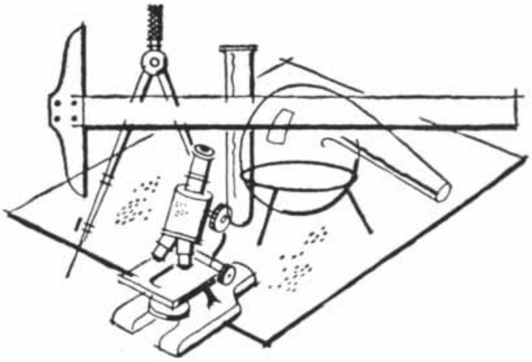
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

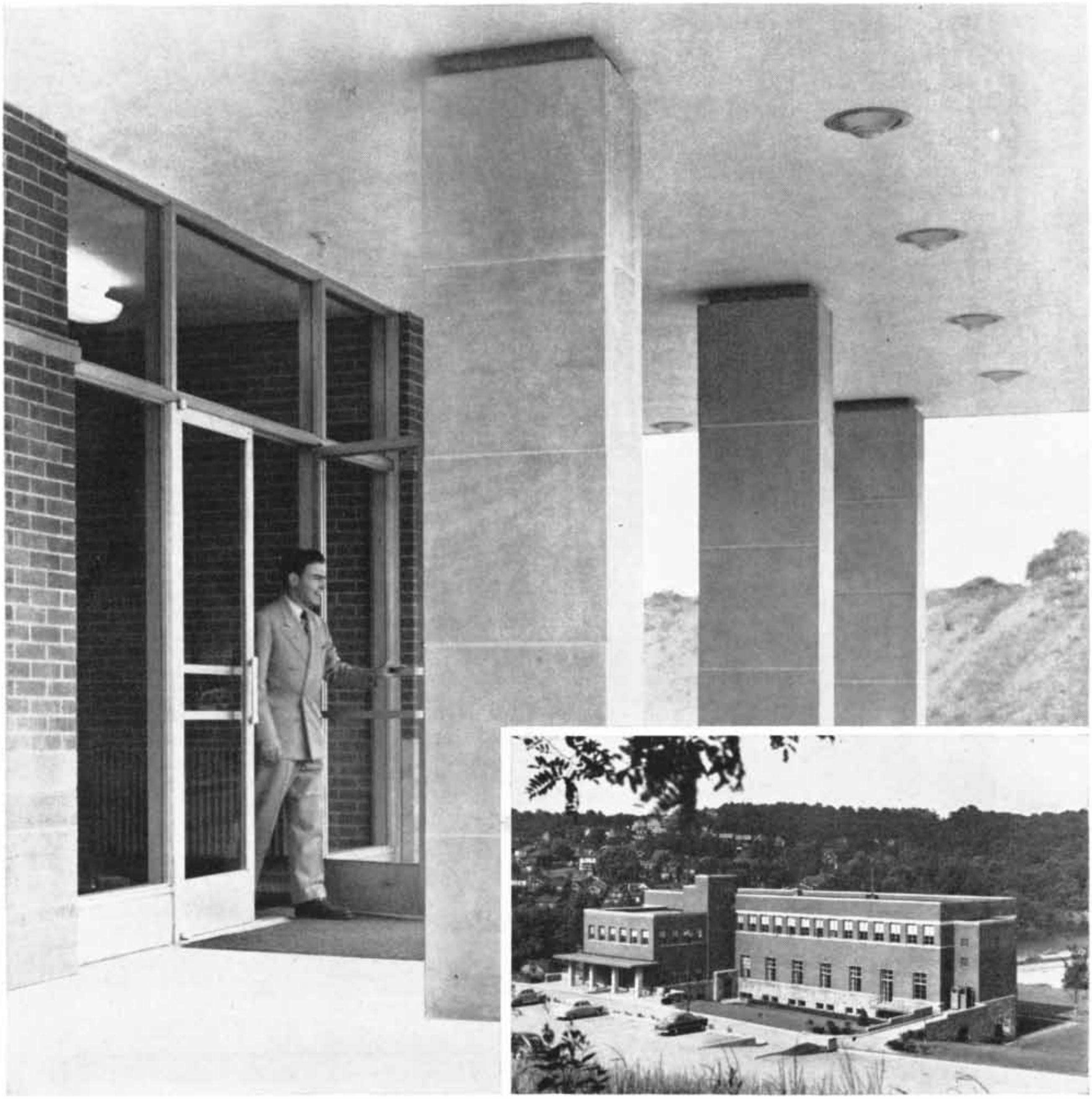
Polychemicals
DEPARTMENT
CHEMICALS • PLASTICS

(*continued from page 18*)

Page	Source
	U. S. Bureau of the Census.
66	Sara Love, from *America's Needs and Resources* (*top*); U. S. Department of Labor, Bureau of Labor Statistics (*bottom*).
67	Sara Love, from data supplied by Karl T. Compton.
68	Sara Love, from U. S. Department of Labor, Bureau of Labor Statistics; U. S. Office of Education, and Association of Engineering Colleges of New York State.
72	Irving Geis, from U. S. Department of Labor, Bureau of Labor Statistics.
73	Irving Geis, from *Science and Public Policy,* a Report to the President by John R. Steelman, Chairman of the President's Scientific Research Board; estimates by the Department of Defense (*top*). From *Manpower for Research,* a Report to the President by John R. Steelman, Chairman of the President's Scientific Research Board; estimates by U. S. Department of Labor, Bureau of Labor Statistics (*bottom*).
75	Irving Geis, from *Employment, Education and Earnings of American Men of Science,* U. S. Department of Labor, Bureau of Labor Statistics.
80	Sara Love, from *Vital Statistics of the U. S., 1948.*
82	Sara Love, from *Medicine, Mobilization and Manpower,* an address before the Council of Medical Education and Hospitals of the American Medical Association by Howard A. Rusk, M.D., Chairman, Health Resources Advisory Committee, National Security Resources Board.
90-91	Irving Geis, from U. S. Department of Labor, Bureau of Employment Security.
92	Irving Geis, from U. S. Department of Labor, Bureau of Labor Statistics.
94	Irving Geis, from U. S. Department of Labor, Bureau of Labor Statistics.
96	Irving Geis, from U. S. Department of Labor, Bureau of Employment Security.
119	Roger Hayward.



Doorway to



To get off to a fast start in their careers, technical graduates are given extensive training before being permanently assigned at Westinghouse. Reason, indeed, why young men who complete their training consider this the Doorway to a Brighter Future.

In this Westinghouse Educational Center, hundreds of experienced professional people help carry out the Graduate Student Training Program, as well as the Graduate Study Program, through which advanced degrees may be obtained.

A BRIGHTER FUTURE...

Recognizing that scientific development plays a fundamental part in the progress of our country, Westinghouse has encouraged it in many ways:

Technical and scientific training of men, and making the most of scientifically trained manpower, is an important responsibility at Westinghouse. So important, in fact, that a new building . . . the Westinghouse Educational Center . . . has been designed and built for its training program.

Graduate Student Training Program

Each year, hundreds of technical graduates are assigned to our Graduate Student Training Program at the Educational Center. Here they gain a clear understanding of Westinghouse research, engineering, manufacturing, and application, after which they are able to determine which field offers them the greatest opportunity in which to use their talents.

Graduate Study Program

In addition to the Graduate Student Training Program, an evening Graduate Study Program is available to employes who wish to continue their education beyond the bachelor degree level.

Science Talent Search

Through the Science Talent Search, public attention is focused on the importance of scientific development, and youth with a scientific interest is encouraged to pursue the subject.

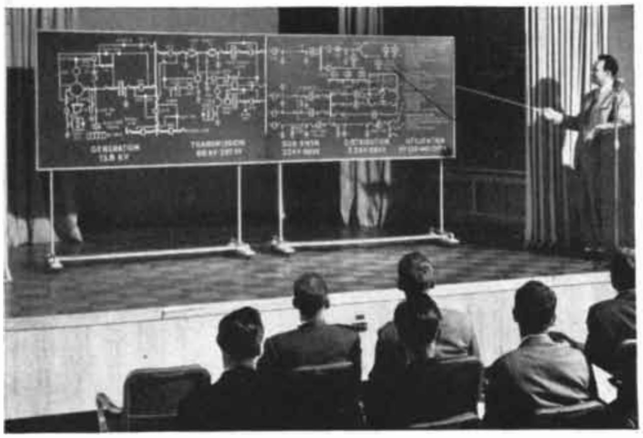
Scholarships and Fellowships

To help hundreds of young men obtain a scientific education, Westinghouse annually offers more than 250 undergraduate scholarships and graduate fellowships.

Westinghouse also provides a summer experience program for engineering professors and for many Ph.D. candidates.

All of these activities by Westinghouse build doorways to a brighter future for the men and women who develop our country.

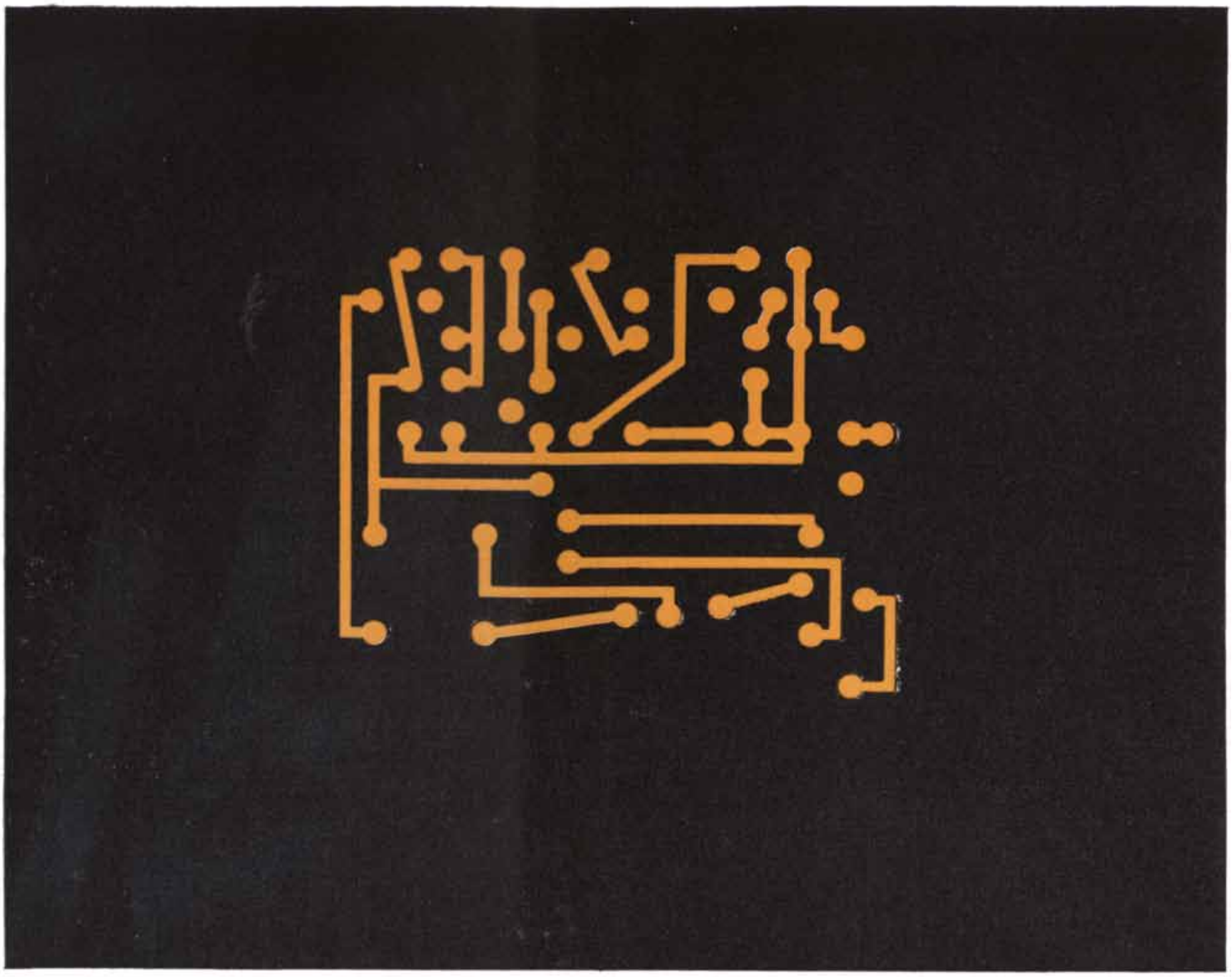
Westinghouse Electric Corporation, Pittsburgh, Pennsylvania. G-10170



Aided by the most modern facilities and techniques, trainees are given a panoramic view of the research, engineering and manufacturing that go into Westinghouse products and the methods used to market them.

In planning the new Educational Center, careful thought was given to recreation. A spacious lounge, hobby and game rooms, a billiard room, facilities for indoor and outdoor sports along with a convenient cafeteria—all contribute to a well-rounded program.

YOU CAN BE SURE... IF IT'S Westinghouse



WORKING DRAWING THAT MEANS...JUST THAT!

Like the 500-year-old invention of movable type, the development of today's *printed* electric circuits makes it far easier and more practical for people to communicate with each other. Printed circuits are simplifying production of hearing aids, radio and television sets, and electronic test equipment. They have made such articles smaller, lighter, more reliable, easier to maintain, and lower in cost.

A printed circuit is a working drawing—*working*. A typical one is made by simple photoengraving of a diagram on a light-sensitized, copper-clad, laminated plastic sheet. When the unwanted copper has been etched away, the remaining copper becomes the permanent electrical conductor, in any desired circuit configuration.

BAKELITE Bonding Resins firmly hold the copper to the base sheet, resisting the attack of engraving chemicals. Later, they withstand the heat of soldering and use. The base sheet is a low-loss, paper-base plastic laminate made with BAKELITE Phenolic Laminating Resins.

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The contribution of Bakelite engineers to printed circuits is the providing of resins and plastics with the required properties. Such properties as bond strength, resistance to thermal shock, dielectric constant, power factor and moisture absorption, are broadly controllable in these BAKELITE Plastics and Resins.

Perhaps there is one that can be fitted to your particular needs. Outline your problems. Call us in to confer. Write Dept. CJ-42.

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SCIENTIFIC AMERICAN

Established 1845

CONTENTS FOR SEPTEMBER 1951 VOL. 185, NO. 3

THE HUMAN RESOURCES OF THE U. S.

DEPARTMENTS

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SCIENTIFIC AMERICAN

SEPTEMBER 1951 VOL. 185, NO. 3

The Human Resources of the U.S.

THE U. S. is a fortunate nation. It is rich in the gifts of geologic time—climate and land, minerals and fuels. Out of these natural resources have grown our bounteous agriculture, our advanced technology and our people—150 million strong.

Although our population rests upon natural resources, it is a natural resource in itself. It is a biological resource, and like other biological resources it is capable of replenishing and increasing itself. And like all natural resources it can be husbanded or squandered, spent wisely or foolishly.

The U. S. has not always spent its resources wisely. In recent years we have become aware that such of our resources as forests, soil, iron ore and petroleum are finite, and we have begun to develop a conscience about their conservation. There is good reason to believe that we should be even more concerned about the conservation of our human resources.

This issue of SCIENTIFIC AMERICAN is solely devoted to an assessment of our human resources. The articles that follow reflect a particular concern with the intellectual component of these resources, because it is in this area that our problems of conservation have become most urgent. Since the turn of the century the evolution of our industrial society has demanded that an increasing proportion of our people work principally with their brains. Already we have an acute shortage of scientists and engineers; our national strength would appear to depend on doing something about it.

Such problems come before us at a time of international tension, but they transcend crises. There is danger, in fact, that we do not take the long view of them. In expanding our armed forces and our production of arms we have already made some important decisions as to how we shall spend our human resources. Before us lie even more momentous decisions as to how we shall spend them without drawing too heavily on those of the future. A policy of emphasizing our immediate objectives at the cost of such long-range necessities as education and pure scientific research may strengthen us for five years, or even ten, but what of the next twenty years, or fifty?

The eight outstanding authorities who discuss these questions in the following articles are concerned with both the short-range and the long-range aspects of the problem. Beginning with an appraisal of our population resources as a whole, these authors go on to consider the size and skills of our labor force; our intellectual resources; our situation in engineering, science and medicine; the demands and effects on our present mobilization, and the future facing our youth.

POPULATION

In 50 years it has grown from 75 to 150 million. An account of its principal characteristics, how they have changed in the past and how they appear likely to change in the future

by Frank W. Notestein

THE tense international situation and our experience in Korea seem to have fostered many misconceptions about the power position of the U. S. We hear talk of our being hopelessly outnumbered in a struggle for survival with the rapidly increasing peoples of the Far East. This pessimistic account runs to the effect that our population is small, whereas the Far Eastern population is huge; that our numbers are not increasing, while unlimited reproduction is multiplying those in Asia; that our nation is no longer rich in young men, whereas China's population is heavily loaded with youths. From these notions many draw the inference that our power is waning while that of the Far East is rising rapidly. Actually there are several errors in this picture.

It is true that the U. S. has a very small part of the world's two and a third billion people: in 1950 only six out of every 100 of the world's people lived within our continental boundaries. But our proportion of the world's population has been increasing, not falling. A hundred years ago the U. S. accounted for only two per cent of the world population, and 50 years ago only five per cent. Our population has increased more rapidly than that of the world in general or of the Far East in particular. It is increasing more rapidly now, and may well continue to do so for some time to come. Moreover, a larger proportion of our population is in the age groups from which the labor force is drawn, and we probably have even a larger proportion in the ages between 20 and 40 than China has.

Most important, we are much the healthiest and wealthiest of the world's great powers. Our influence and that of our friends in the Western world has never depended mainly on numbers; we always have been, and shall remain, a rather small minority of the world's people. The prosperity, prestige and power of the U. S. have been based largely on the rich natural resources at our command, our excellent health, our high skills and our effective political and economic organization. Taken together, these spell large per capita production. In agriculture we make more efficient use of our manpower than most other countries. Whereas in Asia three or four out of every five workers work on the land and produce only a meager per capita supply of food and fiber, in the U. S. our people are fed and clothed much better with only about one worker in every eight working on farms. This leaves the other seven of the eight available for nonagricultural pursuits. That circumstance, coupled with our high industrial efficiency, accounts for the fact that the U. S., with only about six per cent of the world's population, produces almost one half of the world's industrial goods.

The huge population of Asia (well over a billion) and its very high birth rates are not the threat to our leadership that they may seem. With the mass of the population living close to the margin of subsistence, the death rates in the Far East are tragically high, so the rate of population increase is in general rather low in spite of the high birth rates. Any substantial reduction of the death rates through improvement of the food supply would bring a rapid population increase, but the new mouths to feed would absorb most of the increased production; hence it will be extremely difficult to achieve sustained improvements in living conditions. For some decades to come the situation in Asia spells poverty and not power—except power to absorb suffering and punishment. The fact is that the Far East probably would be more prosperous and more powerful if it had half as many people as it has now.

IT IS not in the Far East but in Eastern Europe and the U.S.S.R. that the most significant new developments are occurring. This quarter of the world has a large population which until recently has been technologically backward. But these peoples are now rapidly acquiring the skills needed to turn their fairly abundant resources into economic products. Barring major catastrophes or the grossest sort of mismanagement, they should achieve rapid increases in per capita production and in population during the next few decades. In industrialization they should advance rapidly because they are moving along a path already well charted by the Western world. Their populations should grow swiftly because they are getting the knowledge and the production with which to reduce their high death rates. This segment of the human race is the one that would seem to have the best chance, among the hitherto backward peoples, of becoming a major new focus of political power in the world and of maintaining its position.

All this suggests two major guides to policy for the U. S.: 1) as a small minority people it will be well for us to gain and keep as many like-minded friends as possible; 2) as the more numerous peoples modernize themselves technologically, we shall be able to maintain our leadership in peace and war only by rapidly increasing our own efficiency. In other words, our leadership in the future, as in the past, must be based on quality of performance, not on the number of people. The task is not a simple one, for it requires ever-advancing innovation.

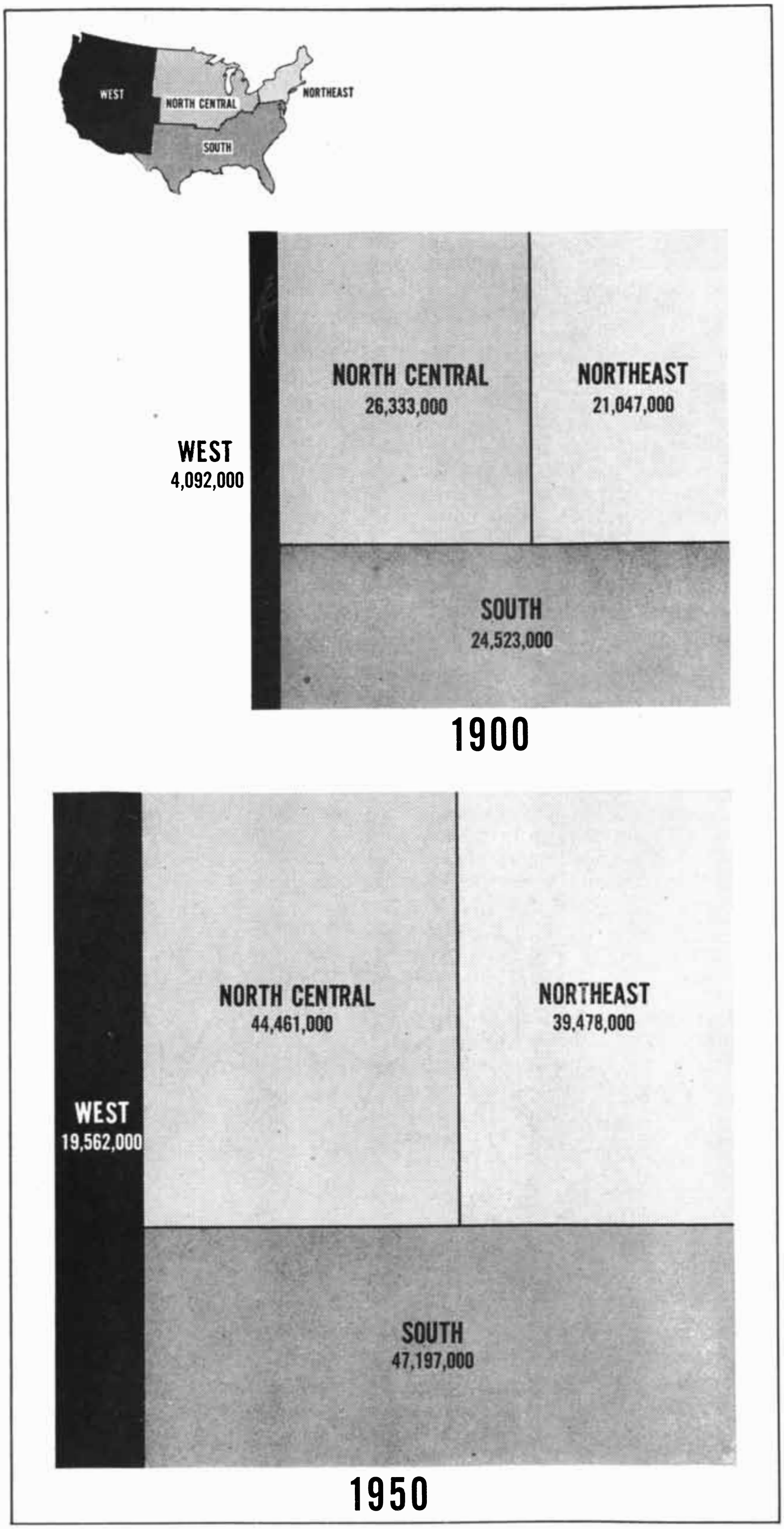
LET US look at our recent population trends to see in what directions they seem to be taking us. During the past 100 years the population of the U. S. increased more than sixfold, while the world's population only doubled; our average annual rate of increase was almost two per cent, in contrast with about three quarters of one per cent for the world as a whole. This increase was due only in relatively small part to immigration; most of the growth was accounted for by the native-born white population. But our rate of growth has been falling decade by decade. It dropped from three per cent a year between 1850 and 1860 to .7 per cent a year in the depression decade 1930-1940. In the 1940s there was a spectacular resurgence of growth; we added 19 million to our population and the average annual rate of increase was twice that in the 1930s. Whether this was a temporary spurt or a permanent change of trend remains to be seen; we shall return to that question later. First let us consider the changes in the composition of our population.

Between 1900 and 1950, when the total population almost doubled, the rural population increased by only a little more than one-third. By 1950 the people living in rural areas, including unincorporated villages and towns, amounted to only 41 per cent of the total population. Those actually living on farms, not all of whom gained their livelihood from agriculture, constituted 16 per cent of the total. Thus in 1950 a farm population some millions smaller than that of 1900 was producing a more ample food supply for nearly twice as many people. The shrinkage of the farm population does not mean that it produced less than its share of the nation's natural increase. With its high birth rates and favorable death rates, it contributed more than its share to the growth of the population, but as job opportunities on the farm shrank, there was a huge and continuous movement of farm sons and daughters toward the cities. Farm families have done extraordinarily well in supplying the nation both with food and with the people to eat it.

During the past 50 years great changes also have occurred in the regional distribution of the population. The sections that have shown the most marked growth are the South, which had the largest absolute increase in numbers, and the West, which had the largest proportionate increase. The two regions achieved their increases in diametrically opposite fashions. The South has grown mainly because of a very high birth rate, which has more than offset the fact that more people have migrated away from the region than to it. The West, on the other hand, has had a comparatively low rate of natural increase, but it has grown prodigiously by attracting migrants from other regions. In general the highest natural increases have come in areas of low economic opportunity. The freedom of internal migration in the U. S. has been one of the sources of our great economic strength, for it has permitted the flexible adjustment of discrepancies between the rate of natural increase and economic opportunity in a region. People have been able to move easily to areas where economic expansion is taking place. Without such migration, the regional differences in the levels of living and per capita productivity would be very much greater than they are.

Another great element of strength in our demographic situation is the age composition of the population. In our population only a little more than one-fourth are children under age 15, whereas in Asia, for example, about four persons of each ten are in that generally unproductive group. The rearing of children of course is the soundest investment that a nation can make, and in our case the investment is a particularly good one, for at current rates of survival more than 95 per cent of those born will live at least to age 15 and more than 60 per cent will live to age 65. But in the Far East the investment is much more precarious; a conservative estimate is that a smaller proportion of those born live to age 15 there than live to age 65 in the U. S. Probably more than 40 per cent of the children in the Far East never reach the productive years of life.

A HUNDRED years ago our own age distribution was much like that of the Far East today. The median age of our population was only 18.8. Fifty years ago it had risen to 22.9. Since 1900 the picture has changed radically. At the turn of the century the age structure was represented by a pyramid that was broadest at the base (representing the number in the youngest age group) and narrowed in rather regular steps for each



REGIONAL DISTRIBUTION of the population has changed greatly during the past 50 years. The population of the South grew the most numerically; the population of the West, the most proportionately. The South had the highest birth rate, which offset the migration of people away from it. The low birth rate of the West was offset by the migration of people to it.

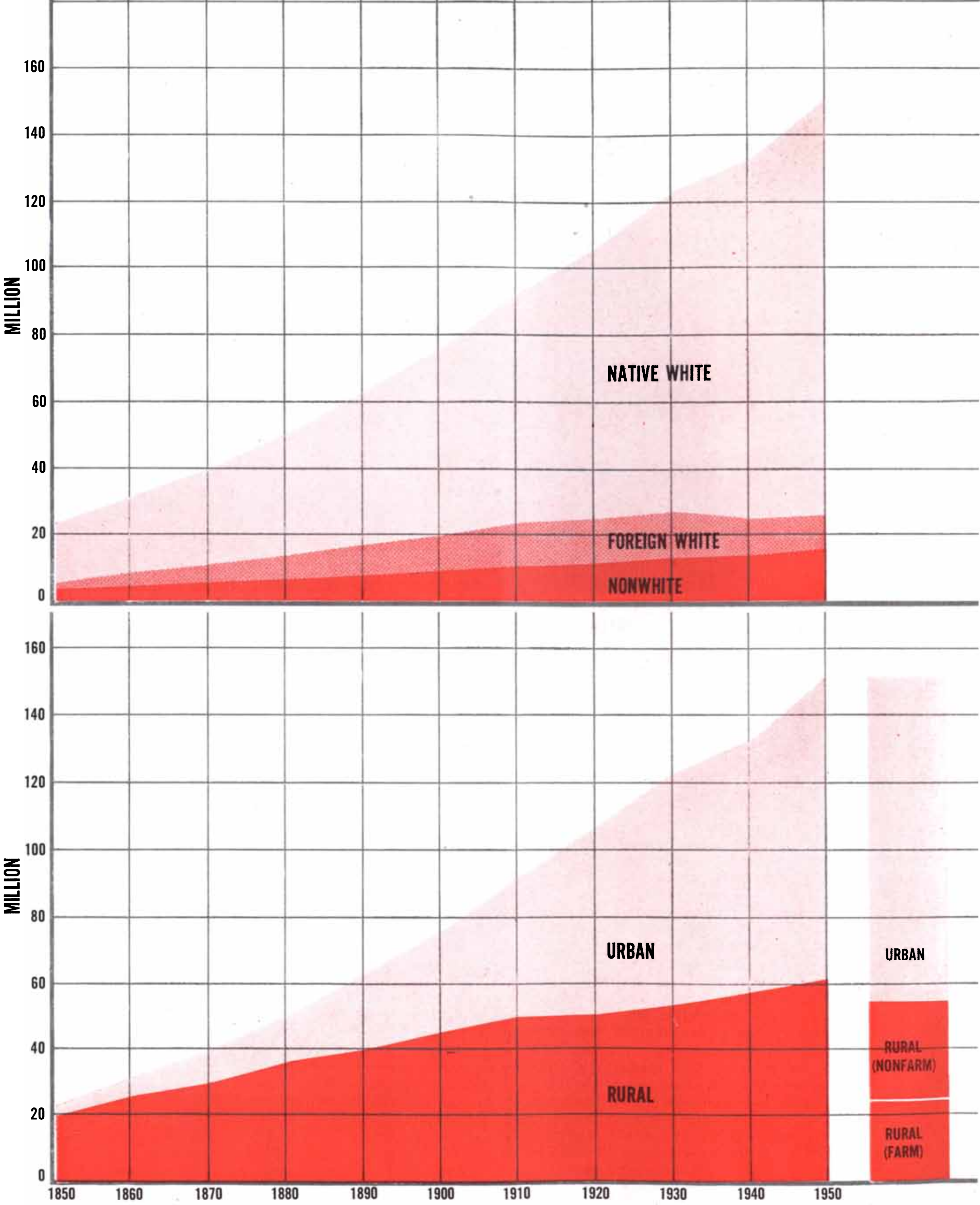
five-year age group from youth to old age (*see pages 32 and 33*). This structure reflected the fact that both the birth rates and the death rates before 1900 had been high: each year's crop of babies was larger than that of the year before, and the older birth classes, besides being smaller to begin with, had tended to die at a relatively early age.

Now the way to produce an older population is to cut both the risks of death and the rate of expansion of the birth crops. Since 1900 the U. S. has done both, with the result that the median age of the population has risen to 30.1. By 1940 the base of the pyramid had been sharply narrowed, because of the decline in the number of births. At that time many demographers, including the writer, suggested that the U. S. might reach its maximum population in a few decades. But events in the 1940s upset these predictions. Death rates declined with unexpected speed, and birth rates rose spectacularly. The base of the age pyramid broadened again. The pyramid for 1950 in the illustration on pages 32 and 33 clearly shows the extent of our error, and should warn the reader that current predictions also may be invalidated by future events.

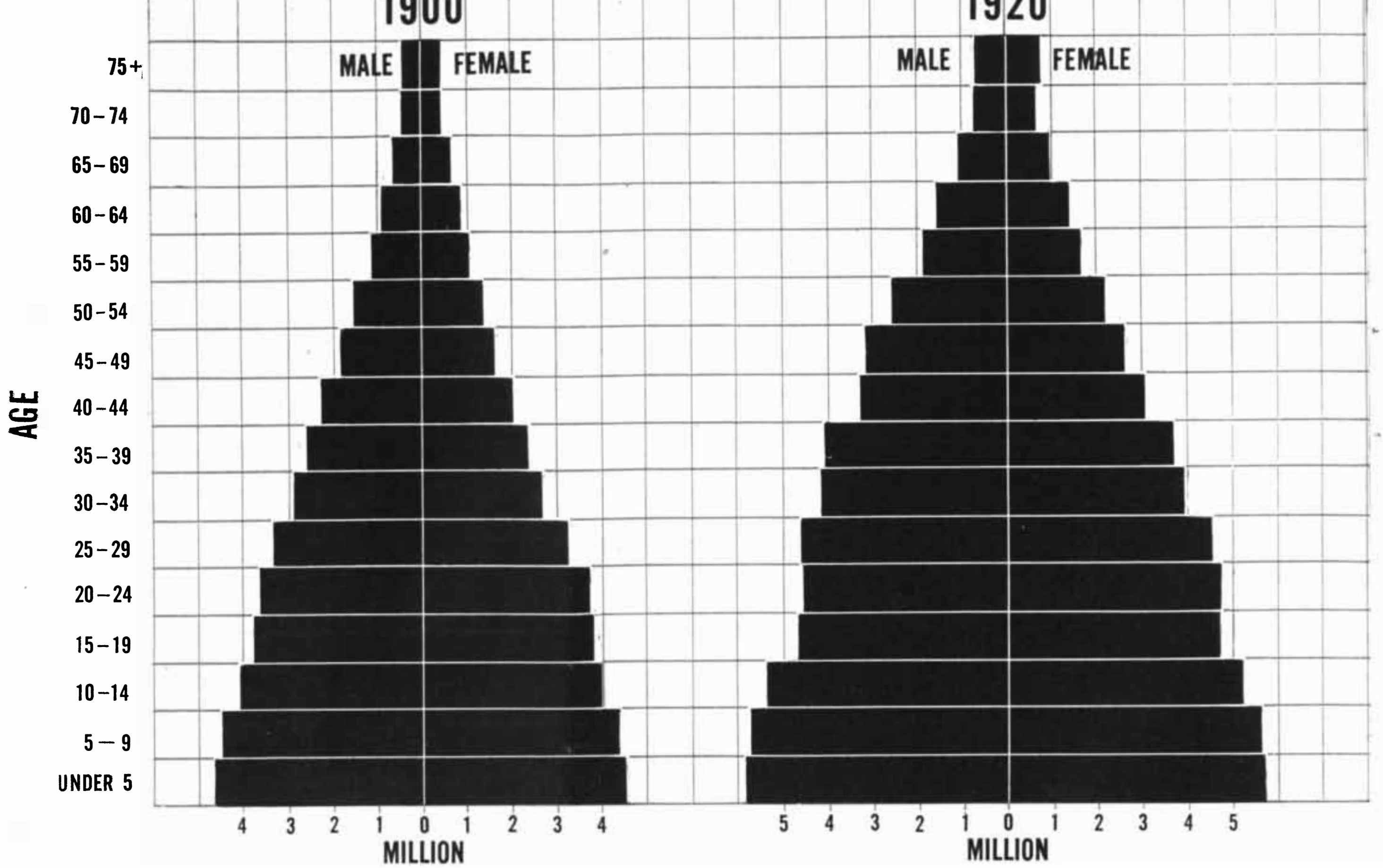
We had a dip in the number of births during the depression and a sharp rise during the 1940s. As a result there will be considerable swings in the next few years in the size of classes coming of age for school, military service, work and marriage. We have already felt the complications of these changes. At a time when the armament program and the new upsurge of population growth are creating inflationary pressures, the annual additions to the productive group are relatively small, because the people who are now moving into the military and working ages are the reduced birth classes of the depression years. The fluctuations in the size of the birth classes will, of course, be felt for many years, as wave following trough breaks on the schools, the labor market, the hospitals, the pension funds and the insurance systems.

Thus far, however, the recent swings in births have not changed the total picture much. In 1950, as in 1940, about 58 per cent of the population was of working age, as against 45 per cent in 1850. In the past 100 years the proportion of old dependents in the population has risen considerably, but the proportion of young dependents has declined sharply, the proportion of young workers has increased somewhat and the proportion of old workers has more than doubled. In short, from the point of view of economic productivity the age distribution of our population has been improving. If we make effective use of our older workers, in all probability that improvement will continue.

This brings us to the consideration



SIZE of the population went from 23,192,000 in 1850 to 150,696,000 in 1950. The diagram at the top of the page shows that the principal constituent of this growth was the multiplication of native whites. The diagram at the bottom of the page shows that the urban population grew at a much faster rate than the rural. In the column at the lower right a new set of definitions has been applied to our present population. This shows that the proportional decline of the farm population is even greater than that suggested by the decline of the rural.



AGE AND SEX DISTRIBUTION of the population notably shows the effects of the economic depression of the 1930s. The pyramids on these two pages show the number of men and women in each age group in 1900,

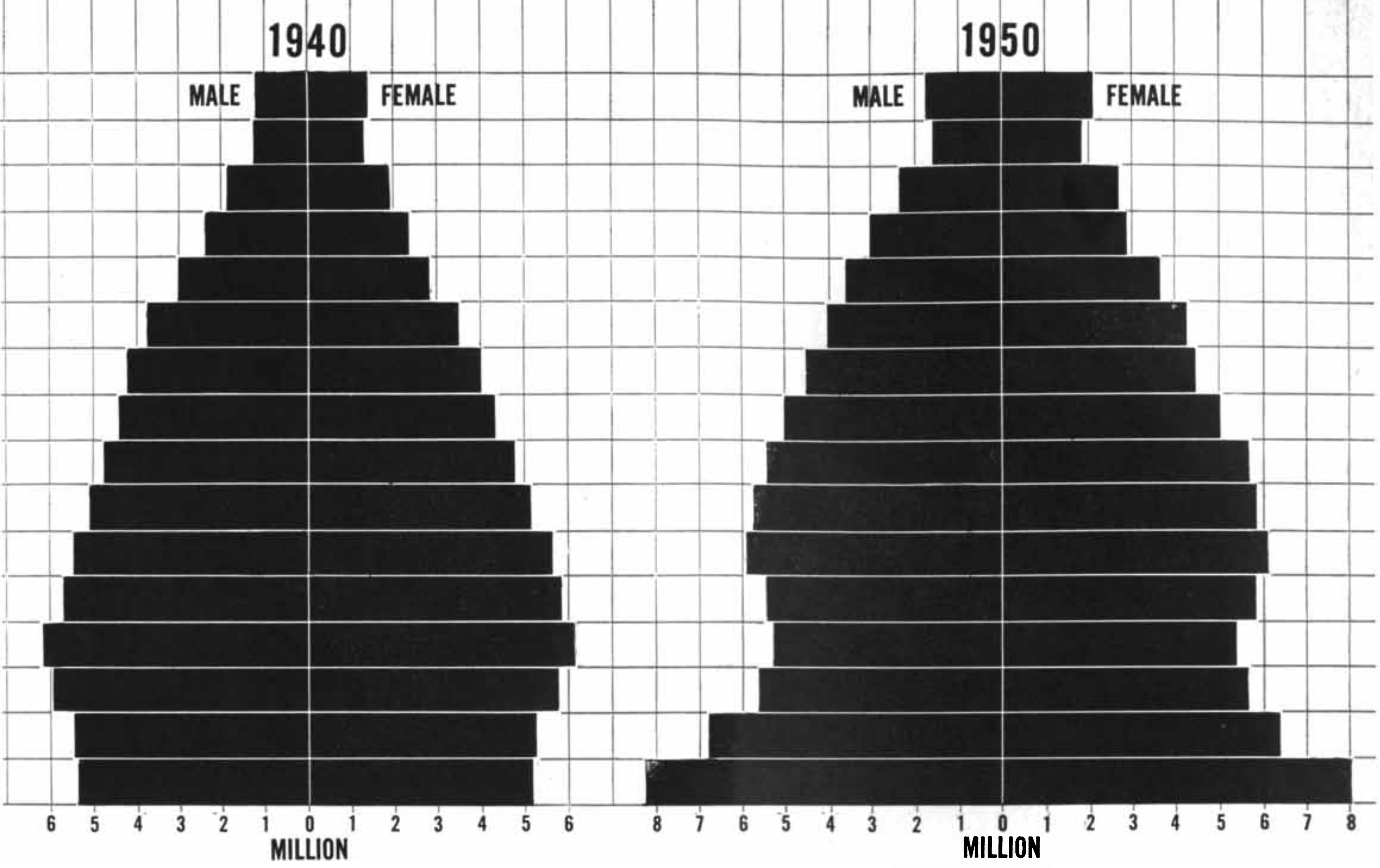
of what the future trends in our population are likely to be. Predictions are risky, as we have seen, but we have some facts to go on and can examine the possibilities. We shall leave out of the discussion the uncertain factor of immigration, which has played an important, though not predominant, part in our population growth in the past. We might increase our numbers greatly by opening the doors again, for it is clear that so long as the U. S. remains free and wealthy in a poverty-stricken world, we can have as many newcomers as we care to accept. But this seems an unlikely event, and in any case immigration policy is a large subject of its own that is beyond the scope of this article.

The two major factors that shape population change in a nation are mortality and fertility. Let us consider mortality first. It can be said at once that the growth of our population would not be affected much by any further reductions in mortality rates, unless we lengthened life by reducing the mortality among oldsters (*i.e.,* over 60). A statistical example will illustrate why this is so.

We shall consider a group of 1,000 live-born white girls. In 1901 the risks of death were such that barely more than half of the 1,000 could expect to live to the age of 60. In 1948 more than half would live to the age of 75, assuming that the death risks remained at the 1948 level. To put it another way, at the 1901 survival rate for white females 1,000 births a year would maintain a total population of 51,000 persons, while at the 1948 rate the same number of births would maintain a population of 71,000, with an average life-expectancy of 71 years. (In India, according to the most recent official life tables—for 1921-1931—the death risks were so high that 1,000 female births a year would maintain a population of no more than 27,000.)

Now most of the gain in average life-expectancy in the U. S. between 1901 and 1948 was due to a spectacular reduction in the mortality of people under 45. There is relatively little further room for improvement in mortality rates below that age. Even if there were no deaths at all before the age of 45 among white females in the U. S., 1,000 births a year would support a population only six per cent larger than the 71,000 figure given above, assuming that the death rates of people above 45 were not reduced. This hypothetical maximum gain of six per cent is much less than the 30 per cent gain that was actually achieved by the reduction of mortality under 45 between 1901 and 1948. By eliminating or greatly reducing deaths before 45 among Negroes, whose mortality rates are still far higher than those of whites in spite of great improvement since 1901, we could add somewhat more to our population potential. But it remains true that the maximum mortality reduction we could achieve for people under 45, or even up to 60, would not greatly increase our population growth. There is, of course, no theoretical limit to the population increases that we might obtain by cutting mortality rates among people over 60; if no one ever died, a population recruited even by only one birth a year would grow indefinitely. Perhaps future advances in the control of the degenerative diseases of old age will have great effects on the size and character of our population, but such speculation seems futile at present. It seems safe to say that the growth of the U. S. population under 60 will not be influenced to any important extent by changes in mortality.

CONSEQUENTLY the major determinant of our growth probably will be fertility, that is, the trend in the birth rate. The events of the past decade have made this very difficult to forecast. Until the early 1940s the direction of the trend



1920, 1940 and 1950. The pyramids at the left are broadest at the base; the pyramids at the right are notched by the declining birth rate of the 1930s. Now, however, the base of the pyramid has broadened again.

seemed perfectly clear. There had been an almost unbroken decline in the birth rate since 1800. All available evidence seemed to point toward a continuation of that decline. The nation was rapidly adopting the small-family system, apparently in all strata of the population. There was ample evidence that the reductions in births were coming about mainly through the growing prevalence and increasing effectiveness of contraceptive practices. It seemed that the people, poor and well-to-do alike, wanted fewer children and were rapidly finding the means of fulfilling that want. Further declines in the birth rate could confidently be predicted.

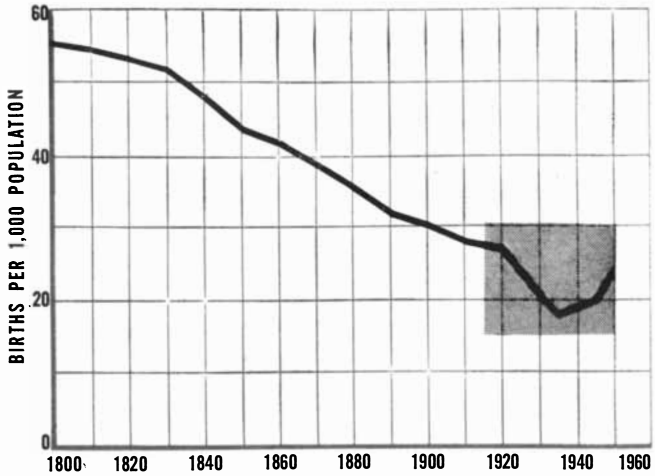
So went the reasoning; the events took another course, as the charts on page 34 demonstrate. From a depression low of 2.3 million in 1933 the annual number of births rose to 3.9 million in 1947 and stayed at about 3.7 million through 1950. But it is far from certain that the birth boom of the 1940s foreshadows a continuation of high birth rates in the future. There are indications to the contrary in some of the characteristics of the boom.

For example, the increase in births has been most marked in those sectors of the population where fertility has been under the most effective control and is normally low—among city families, those living in the Northeast and those with college education. The groups that are usually the most fertile—farm families, those living in the South, those with the least education—had the smallest increases.

Moreover, the indications are that the huge increase in births during the 1940s was due mainly to the fact that more families were having children or adding a second or third child, rather than to any abandonment of the small-family system. First, second and third children accounted for most of the increases in births. It is true that there were also considerable increases in the numbers of families that had a fourth or fifth child, but this appears to be attributable to the fact that more women were exposed to that risk, because of the sharp rise in marriage rates in 1940 and 1941. The actual proportion of mothers who bore fourth and fifth children, of the total number of married women in a position to do so, probably declined throughout the baby boom. Evidence presented by P. K. Whelpton in a forthcoming book entitled *Cohort Fertility* indicates that similar factors also probably account for most of the increase in third births.

The increase in first and second children almost certainly has been due in part to the growing social disapproval of childless and one-child families. If this attitude continues, it will tend to produce a permanent increase in births. However, the increase seems to have been due in even larger part to the fact that people have been marrying at progressively younger ages, which has resulted in a very large increase in the number of marriages. This process cannot go on indefinitely. When the trend toward earlier and earlier marriage ages stops, the marriage rate will fall sharply, and if the marriage age should then rise, the drop in the number of marriages would be precipitous. That in turn, of course, would result in a sharp drop in the number of births.

THESE considerations lead us to wonder whether the baby boom of the past decade may not foreshadow a rather sharp decline in births during the next few years, instead of marking the beginning of an upward trend. To be sure, the fact that couples marry younger means that the wife is exposed to the possibility of having children for a larger part of the child-bearing period of her life, and the parents therefore have more



FERTILITY of the white population steadily decreased from the 1800s to the end of the 1930s. The diagram at the right shows in greater detail the area indicated by the gray rectangle on the diagram at the left.

chances of exceeding the number of children they want or more time to change their minds about wanting additional children. On the other hand there is every indication that the major part of the increase has come from those sectors of the population that have their fertility under the most effective control, and the increase from this group may be canceled to a considerable extent by the continued decline of the truly large families—a decline that has gone on throughout the baby boom.

On balance, it now seems that we should expect a considerable recession from the high birth rates of the 1940s before very long. It is unlikely, however, that we shall return to the low birth rates of the depression years in the foreseeable future, provided the marriage age stays young and the proportion of those who never marry does not increase. No one knows whether these conditions will continue. We have learned a good deal about the manner in which the resurgence in births developed, but we still know rather little about the motivating forces. Evidently the revival of the economy after the great depression released a backlog of postponed marriages and births. Clearly also, the Government strongly encouraged a rise in the birth rate, without explicitly planning to, first by exempting married men from conscription, then by exempting only those with children and finally by providing family allowances and free maternity care for the wives of the fathers it drafted. Veterans' benefits also contained family allowances, and under their provisions marriage was no longer a deterrent to advanced education. The expansion of social security, increases in tax exemptions for dependents, the current period of full employment—these, too, probably have had something to do with the increases in births. The present military service act, which defers the induction of fathers, adds a new stimulus to procreation.

Yet we do not really know what were the most important factors behind the baby boom; it is possible that less tangible causes, on which no systematic evidence is available, have been more influential than any we have mentioned. Apparently the wartime experience taught young America that it was fun to marry young and rear a small family, especially when it could be done with financial assistance from the Government. If this is so, and if new economic difficulties do not arise, we may expect the stream of births to be sustained well above that of the depression years, though below the current level.

OUR population should therefore continue to grow, at a rate somewhat lower than that of the 1940s. But we are not in a position to make any precise estimates of our future size; there are too many unknown variables at work. The measure of that uncertainty can be seen in the fact that the most recent population projections by the Bureau of the Census for the year 1960 range from a low of 161 million to a high of 180 million.

It is by no means certain that it would be to the advantage of the nation to have a continuation of the recent high rate of population increase. Growth of the population reduces the amount of natural resources available per person, which means that the nation must turn to the use of inferior or substitute resources, and such uses generally entail higher costs. Technological advances may well cancel such added cost, but income used in canceling higher costs is not available for other uses. From the standpoint of the economic welfare of the population as a whole, the only economic advantage that comes from a large population as such lies in the economies it makes possible through specialization in production. It is not at all certain, however, that larger numbers would greatly increase such economies in the U. S.

Rapid growth undoubtedly supplies a kind of stimulus to the economy, making it more dynamic and flexible, but growth is only one of the ways of achieving this, and if the costs of the growth are high, it may not be the most efficient way. Precipitous changes in the rate of growth are troublesome. As we have seen, such changes introduce waves and troughs into the age distribution, and these require the nation to maintain more facilities to care for its population than it would if the same numbers were distributed more smoothly over the life span. School buildings are one striking example; they must be built to take care of peaks of population. The ebb and flow of births is, in the long run, a costly affair.

From the military point of view the matter of population size may have a somewhat different aspect. Even from this point of view, however, it is questionable whether the desirability of a larger population is as great as is commonly supposed. Since our population will in any case remain a relatively small one in world-wide terms, our main asset lies in our power to produce more material than we require to maintain ourselves. This asset can be retained only if we are able to invest heavily in the health and training of our youth, which involves retaining a high level of living. These considerations suggest that it is wise to avoid growth that presses on our resources, even when the object is to maximize national power. On the whole it seems to the writer that the nation is fortunate to have come through its period of rapid growth without generating a population that seriously strains our resources.

FROM the point of view of power and economic welfare the characteristics of the population may be more important than its size. One of our most important assets will continue to be the favorable distribution of the population between the working and the dependent ages. The value of this asset will depend to a considerable extent on the effectiveness with which we employ the older worker. The number of young workers will continue to grow, but the older workers will increase even more rapidly. The aged will increase most rapidly of all. The "problems of the aged" are difficult human and social problems, but these are minor liabilities of one of our most magnificent assets—the fact that relatively little of the life created in the U. S. is lost before it reaches the age when it can contribute to the social product.

If the strength of the nation lies less in numbers than in per capita productivity, then we need to place great and growing emphasis on the quality of the population. Here we have some disturbing problems. The uneducated and the poor continue to produce a disproportionate share of the nation's children, although the disparity has narrowed in recent years. While it seems likely that in all the principal groups in our population the majority are fairly sound stock, from the point of view of the nation's skills it is surely unfortunate that a disproportionately large share of the children are reared by parents with the least education and the least ability to provide for their children's education. Similarly, it is unfortunate that the states whose high birth rates produce the heaviest educational burdens are also the ones least able to carry the loads. If the leadership of the U. S. is to be maintained, in our increasingly complex world, it is essential that we develop the skills of all our people to the maximum of their inborn potential. This we have not done, and shall not do until the ability of the child replaces the income of the parents as the major criterion for educational opportunity.

IF THE population problems facing us in the future seem difficult, it may be pointed out that under peacetime conditions the problems ahead will be small compared with those already solved. Western civilization for the first time in man's long history has learned to substitute the control of fertility for death as a means of checking unlimited increase. Our reduction of peacetime mortality since 1900 has saved many more lives than have been lost in the wars of this century. With all our tragic failings we have become relatively efficient producers of life, and given peace and moderate wisdom we should continue to increase that efficiency.

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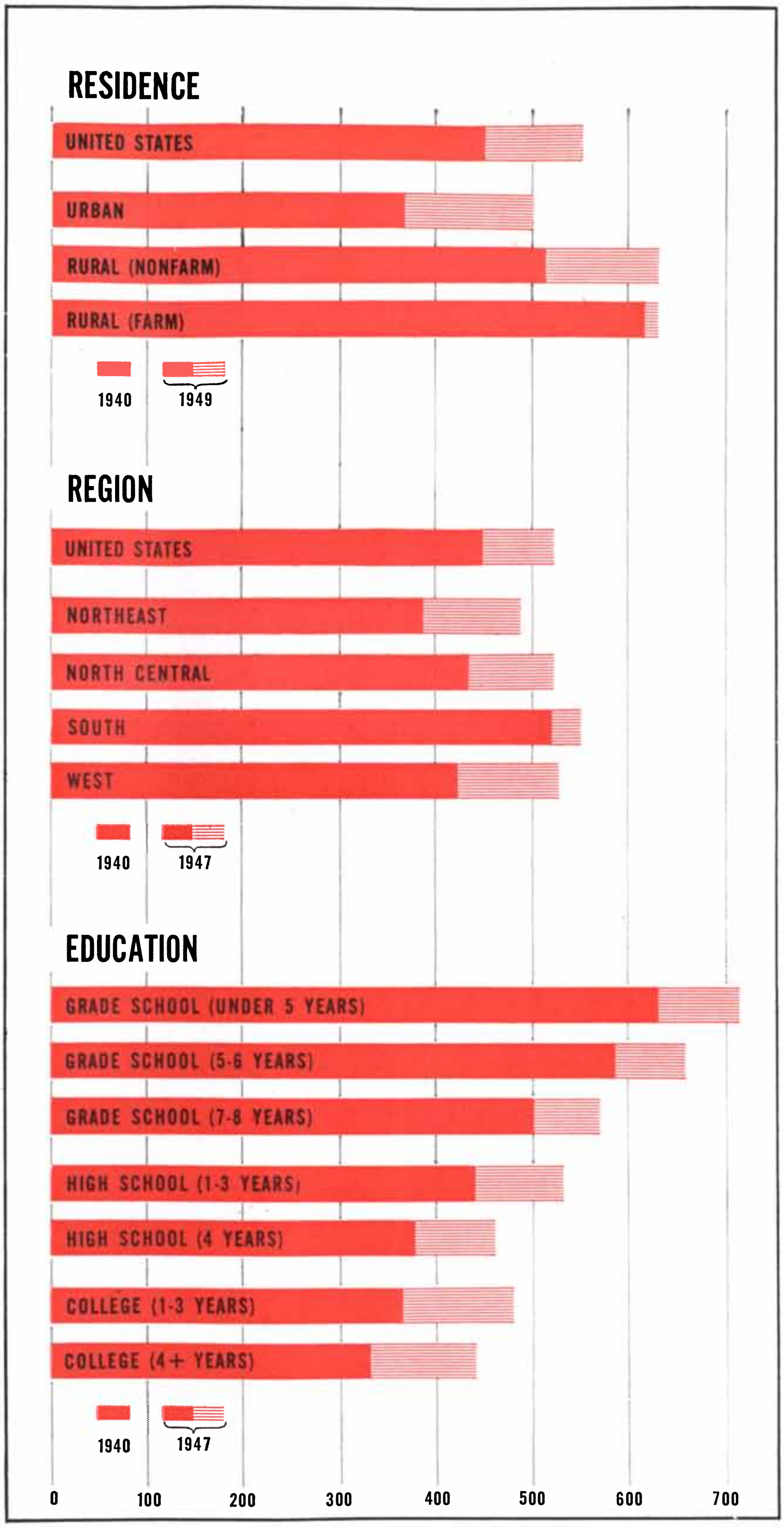


FERTILITY DIFFERENCES among various groups in the population are also in a state of change. The numbers at the bottom of this diagram represent children under 5 years per 1,000 married women between the ages of 15 and 49. Between 1940 and 1949, for example, the fertility of the rural population increased little and the fertility of the urban population a good deal.

LABOR FORCE

Sixty million Americans work for pay. Our increasing productivity per man-hour frees more and more of us for specialized occupations and at the same time accentuates the demand for trained personnel

by Ewan Clague

THE SIZE of a nation's labor force (in proportion to its population) can vary a great deal, depending on circumstances. There is, of course, a basic core of workers that does not fluctuate much: this consists of the male population between the ages of 25 and 45, about 95 per cent of whom normally work. But every nation has available certain other major groups that participate in the labor force to greater or less degree according to the times, the need and the incentives. These groups are: 1) housewives, 2) teen-age boys and girls and 3) old people. In times of emergency large reserves from these pools of potential workers can move into the labor force and swell it greatly. Over the long run also the proportion of women, youths and oldsters at work may shift considerably. In short, the working force of a nation, meaning the part employed in industry, trade, professions, social services and so on, has a great deal of flexibility, and the country's welfare depends in no small degree on how effectively it makes use of that flexibility.

This article will attempt to appraise the production potential of the U. S. in terms of the size and composition of its labor force—as it is now and as it may be expected to develop in the future on the basis of the trends of the past half-century.

As the preceding article (*page 28*) indicated, the long-run trend in the U. S. is in the direction of an increasing proportion of the population joining the labor force. In 1890 about 35 per cent of the total U. S. population was at work or looking for work; by 1950 this proportion had risen to more than 39 per cent. The chief reason for the increase, aside from the rise in the percentage of adults of working age, was the movement of women into the labor force: the proportion of girls and women working for pay rose from 20 per cent in 1900 to about 29 per cent in 1950. More and more women were, and still are, leaving the home to take regular jobs. Labor-saving machinery in the home, which has given women more time to work outside, and the urbanization of the nation have been largely responsible for this trend; farm women ordinarily do not take outside jobs for pay.

At the same time two other trends operated to check the increase in the labor force. In contrast to the women, the two other groups in our reserve—teen-age boys and old people—were moving out of the working pool. Fifty years ago 50 to 60 per cent of all boys aged 14 to 19 went to work; now, even in the prosperous year of 1950, the proportion has dropped to about 39 per cent. This downward trend is likely to continue. Besides child labor laws and the trend toward staying in school longer through high school and college, there is now a new factor to divert young men from the civilian labor force—compulsory military service. The present prospect is that we shall have a standing military establishment of 3.5 million men. The maintenance of a military force of this size will necessarily draw heavily upon young men of 18 and 19.

Nonetheless, we can take note of the fact that the group of boys aged 14 to 19 constitutes a large potential reserve of workers for an emergency; during World War II they joined the labor force in large numbers.

THE SAME holds true of our older men over 65. The nation has made less and less use of these older citizens in the past half-century. Sixty years ago more than 68 per cent of the men 65 years of age or older were counted in the labor force; today only about 42 per cent are. One reason for the decline is the shift of most of our population from the farm to the city; on the farm it is easier for an old man to keep working, at least part time, than it is in the city. A second reason is the development of social security and pension systems, public and private, which encourage retirement at 65. A third reason is the fact that our present industrial system puts a premium on younger workers.

Yet the older men constitute a human resource that we cannot afford to discard. During the war years many of them returned to work or stayed on past 65, so that the proportion of men over 65 working rose to 50 per cent. Since from the long-run standpoint it would be unwise to draw youths away from schooling into the labor force, and since there are limits to the number of women who can leave the home to work, the older group is likely to become our most important available reserve of workers, particularly as it grows to be a larger and larger proportion of our population with the increasing average life span.

Among U. S. employers it has become a widespread practice to set arbitrary age limits—to hire no one over 45, say, and require all workers to retire at 65. There are some understandable reasons for this policy. When a company has a lot of old people already on the payroll, the management naturally prefers to replace those who retire with young workers who can begin at the bottom and come up through the firm. If it has a pension system, the firm has a strong economic motive to avoid bringing in middle-aged or older workers who will work only a relatively short time before retirement and pensioning. It is also a fact that some older workers are less flexible and adaptable than young workers and may prove to be misfits after being hired. The employer is much less hesitant to take a chance with young workers because he can easily get rid of those who do not work out satisfactorily, whereas older men resist losing their jobs and may appeal strongly to the obligation of the employer to keep them. As for the policy of compulsory retirement, it is motivated, among other reasons, by the fact that older workers often resist any adjustment of job or salary to their failing powers.

But making all due allowances for these reasons, it remains true that the problem is magnified by prejudice, and that an arbitrary policy of this kind is unwise and unnecessary. Most men of 55 to 65, and many of those over 65, make excellent employees. If adjustments in jobs and occupations were made throughout industry, many men in their later years could continue as members of the labor force far beyond present age limits. The employment of older workers could also be facilitated by certain adaptations in private pension systems. The present mobilization emergency may accelerate the adoption of such measures. We are likely to find increasing need to make changes in our society and economic institutions in order to reverse the downward trend in the employment of older people.

At all events, in spite of declines in some sectors there has been a net gain in the size of our labor force in the last 50 years, mainly because of the entry of women in large numbers. Let us turn our attention now to shifts within the labor force.

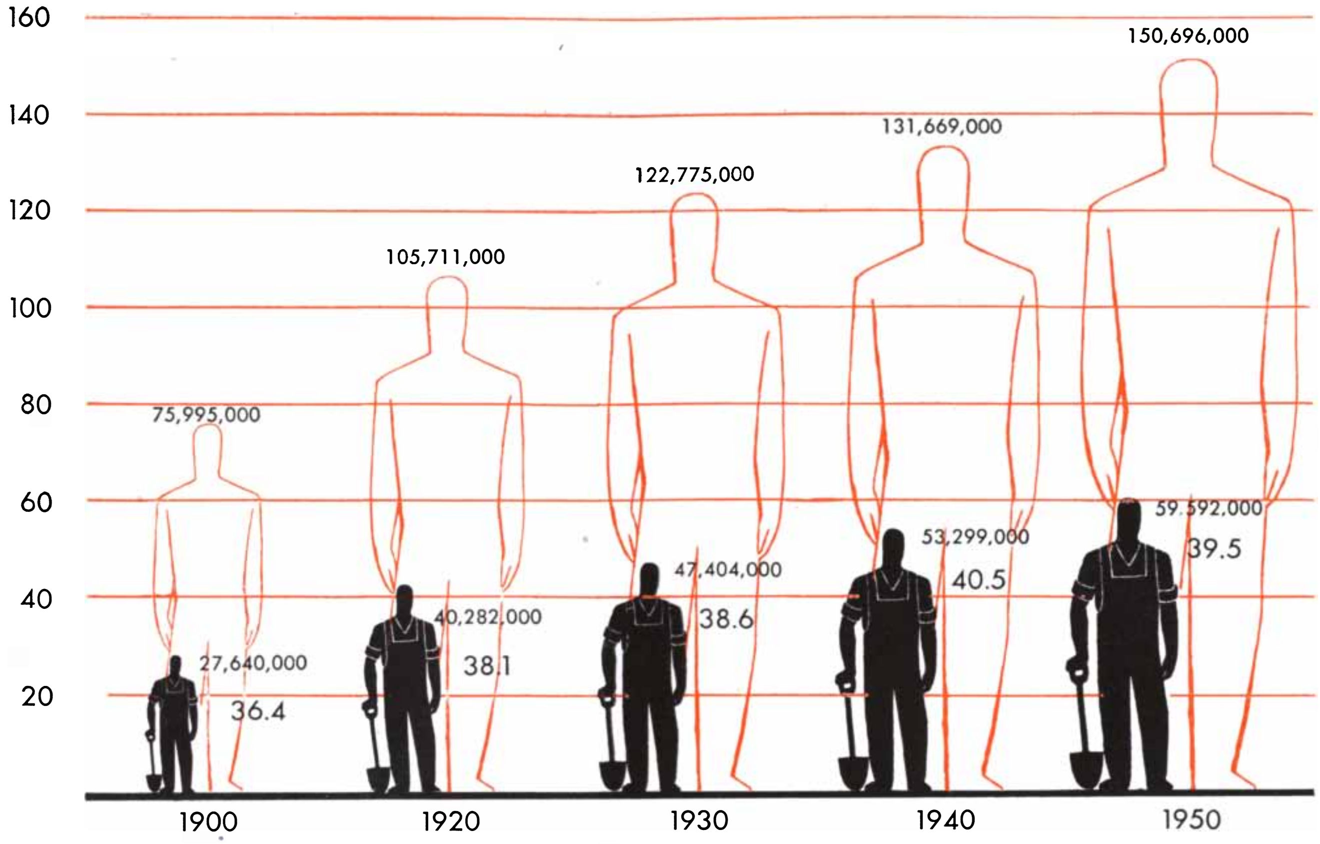
AT THE TURN of the century the U. S. had about 11 million farmers and farm laborers, and they made up about 38 per cent of the total labor force. By 1950 this number had declined by several million, in spite of the fact that the population of the country had doubled and the labor force had more than doubled. The shift from agriculture is still continuing; indeed, it has been markedly accelerated during the present mobilization period. With the help of mechanization, however, the reduced farm force today produces far more food and fiber than did the larger farm manpower of 1900.

The shift of manpower of course has been mainly to industry. The number of workers employed in manufacturing has jumped from 7 million in 1900 to approximately 15 million in 1950; during World War II it rose to about 18 million. Workers in manufacturing now account for 25 per cent of the total labor force. If we add those in mining, construction and transportation, the proportion is about 40 per cent, and the aggregate number in the heavy industries is nearly 25 million.

Most striking of all, however, is the huge expansion in the proportion of our working force devoted to service occupations. Our rising standard of living has evidenced itself not only in the production of goods but even more in the production of services.

Consider first the trade and service industries: retail and wholesale trade, restaurants, hotels, banks, insurance, recreation, and so on. Fifty years ago this whole block of activities employed no more than 8 million workers; in 1950 it engaged well over 23 million—more than the number in manufacturing. In World War II there was a considerable shift from this group to manufacturing and the military forces, but after the war the trade and service industries promptly expanded again.

Even more spectacular has been the rise of that comparatively small but vitally important group—the professional,



SIZE of the labor force with respect to the total population has gradually increased. The numbers at the left side of this diagram are millions of people. The large figures in red represent the total population; the smaller figures in black, the labor force. Beside each of the figures is the number of people that it symbolizes. Beneath each of these numbers for the labor force is the percentage of the total population that it represents.

semi-professional and technical workers. At the turn of the century this whole group numbered only about 1.2 million; now it has grown to almost 5 million and is still expanding rapidly. This is the group which, generally speaking, has always captured the best brains in the nation. In leadership and influence its significance, even in purely economic terms, runs far beyond its numbers.

Within the professions also there have been sharp shifts. Fifty years ago the traditional trinity—the ministry, law and medicine—accounted for most of our professional people. Now other professions, particularly in the scientific and technological fields, enroll as large or larger numbers. The number of engineers, for example, has increased 10-fold: from 40,000 in 1900 to about 400,000 in 1950. Many new professional and semi-professional occupations that did not exist at all in 1900 have sprung into prominence. And it is on the need for scientific and technical personnel, along with doctors, that the chief emphasis is now being placed.

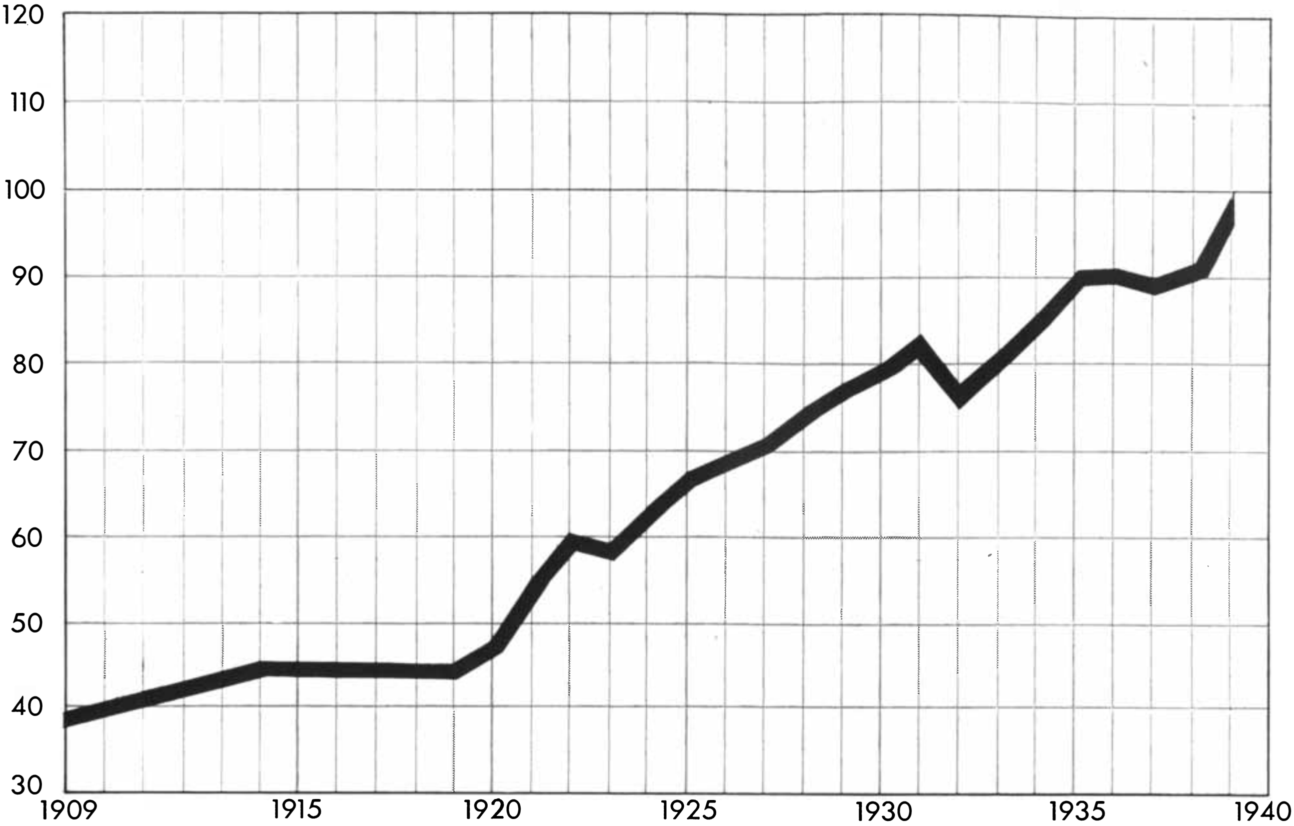
In the labor force as a whole the average of skill today is higher than it was 50 years ago. The proportion of highly skilled craftsmen has just about held its own, but there has been a marked increase in the proportion of semiskilled workers, with a corresponding decrease in the unskilled. In 1910 there were 11 million common laborers in the U. S., half of them on the farms; the number has now shrunk to less than 6 million. Meanwhile there has been a rapid expansion in what the Census calls semiskilled operatives. This carries a certain disadvantage: since their skills are rather specialized, there is a greater tendency for pockets of labor shortages and surpluses to appear. But this effect is comparatively small and it is offset by the fact that workers can learn new skills in a relatively short time.

THE NUMBER of workers and the reckoning of their skills are not the entire measure of the labor force. Quantitatively we must take account of the factor of time worked. The true measure of the size of the labor force is not merely the number of people in it but the total number of man-hours available. From that standpoint the increase in the labor force may not be as great as it appears. In the first place, many of those who have been added to the working force are only part-time workers. This holds particularly for the women, some of whom work at jobs only part of the day or part of the week. Secondly, there has been, as everyone knows, a great reduction of the average full-time work week in the U. S. The effect of this, in terms of production, is not easy to appraise; there are pros as well as cons.

Fifty years ago the standard work week in U. S. industry was 54 to 60 hours, and for many workers it was much longer than that; for example, until 1923 certain types of workers in the steel industry had a 12-hour day and 7-day week. Thus at the turn of the century the typical industrial employee who had steady work throughout the year worked a total of nearly 3,000 hours. Today, with a standard work week of 40 hours, holidays, vacations and so on, a typical industrial worker probably averages no more than 2,000 hours a year. The hours of labor on farms also have declined, though not as much as in industry. Thus the increase in man-hours since 1900, while considerable, is far less than the increase in the number of workers.

An obvious corollary of these facts is that in an emergency we could rapidly expand our labor force, in terms of man-hours, by lengthening the hours. An increase of six to eight hours in the standard week in industries where this is practicable might add the equivalent of 8 to 10 million workers to the nation's total labor supply.

But this would not bring a proportionate increase in production, for the output per man-hour would certainly decline. And there are limits to the feasi-



PRODUCTIVITY of the labor force increased steadily from 1909 to 1939. This diagram shows the rise of productivity per man-hour in manufacturing. The numbers at the left are an arbitrary index. The diagram is not carried beyond 1939 because of the difficulty of comparing productivity statistics in situations of war and peace. It is generally known that productivity per man-hour has increased at an even greater rate since World War II.

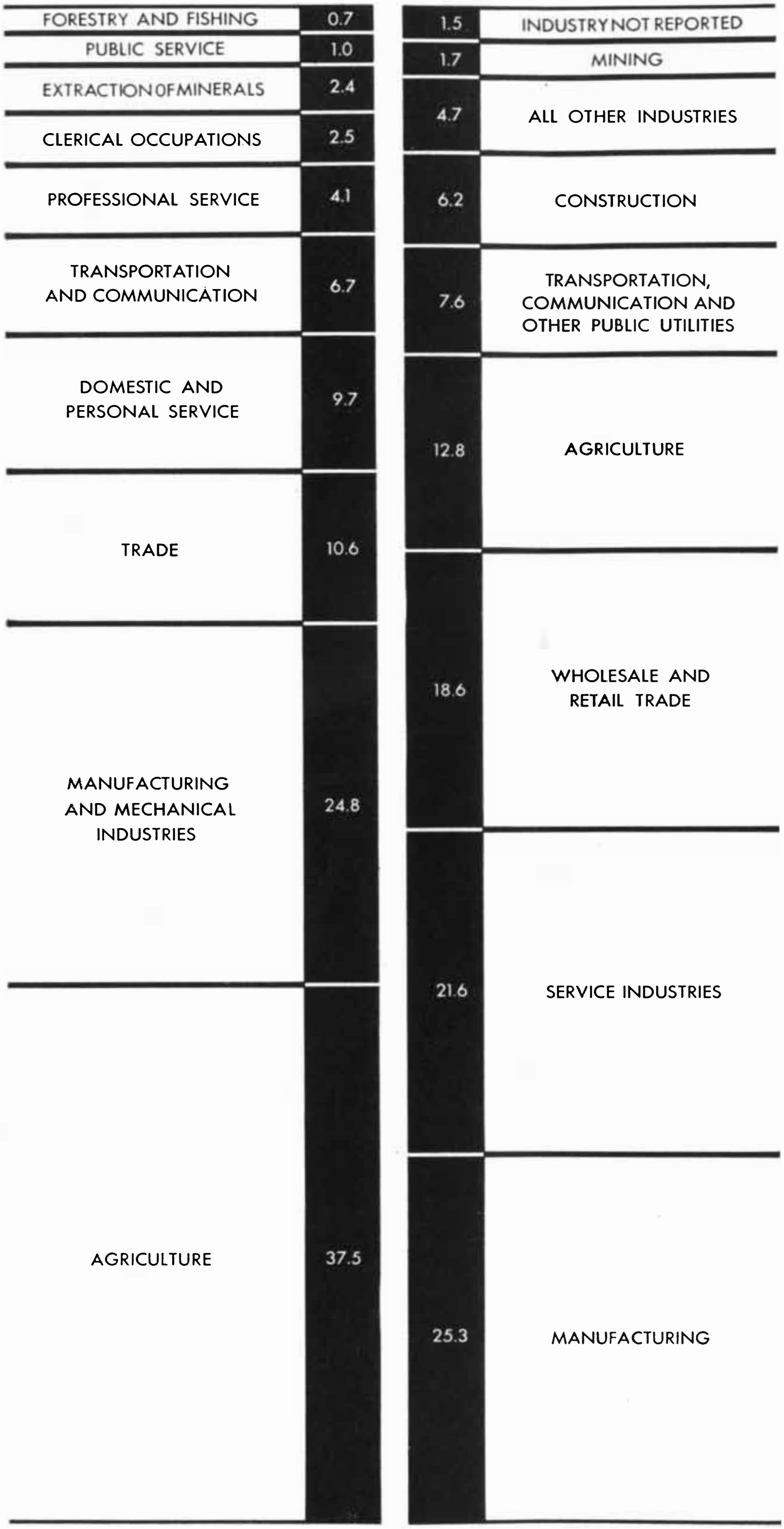
ble length to which hours can be pushed and to the length of time they can be sustained. Great Britain demonstrated this during World War II. In the crisis summer of 1940 the British people worked up to 72 hours a week and achieved a sharp increase in production. After several months, however, the spurt took its toll in fatigue and absenteeism, and production fell off so much that the hours of work had to be cut back substantially.

Actually the great reduction in working hours in the U. S. since 1900 has been to some extent a biological and economic necessity. The long hours of 1900 were made possible by the fact that the pace of the work was much slower than it is now. The enormous increase in the speed and intensity of work in many industries, due to greater mechanization, has made a reduction in hours inevitable. We cannot be sure that 40 hours per week represents the optimum for maximum production in the long run, and it is clear that the optimum would differ for different industries and occupations. But it is also clear that we could not go back to anything like the hours of 1900 at the present tempo of work.

IN ANY CASE, what we have lost in man-hours we have more than made up in the increased productivity per man-hour. In manufacturing the average hourly output of product by the individual worker rose at the average rate of three per cent a year for several decades, even before the acceleration brought by World War II. The gain in other fields has probably been somewhat smaller than in manufacturing, but if we estimate conservatively that the economy as a whole improved its productivity at the rate of two per cent a year, in 50 years the cumulative advance has been tremendous. It is this increased productivity that is mainly responsible for the nation's present high standard of living and its position as the outstanding industrial machine in the world, with six per cent of the world's population producing nearly half of the world's economic product.

In part this accomplishment rests upon the fact that the U. S. labor force in general is probably the most highly trained, experienced, resourceful and flexible in the world. But American labor also has a superior supply of tools and equipment with which to work. The U. S. has far surpassed all other major industrial nations in capital investment and in the invention of new machines, materials and processes. It has also led the world in the initiative and organizing ability of management. The technician and the management expert have more standing and influence in industry in the U. S. than in any other country. Another reason for our high productivity is our strong industrial competition; although trusts, monopolies and agreements in restraint of trade do exist in this country, they have been much less influential than the cartels in other countries. On the whole, competition in the U. S. has been vigorous and widespread. Finally, there is the immensely stimulating factor of industrial research, to which U. S. industry has been devoting a larger and larger portion of its capital investment, particularly during the past decade. The competition for improved products and more economical ways of doing things is so keen that in some industries a successful research laboratory today is the key to industrial survival.

We can sum up the assets of our labor force, therefore, as follows: It possesses high skill and initiative, has excellent technical and management leadership and is tooled with the most powerful industrial machine in the world. Our average level of education and occupational training has risen constantly during the past half-century, and the trend suggests that it will rise to much higher levels in the future. We have a growing population, and the ratio of the labor force to the total population is steadily increasing. Our advances in health and the re-



KINDS OF WORK occupying the labor force have changed greatly from 1900 (*left*) to 1950 (*right*). The percentage of the labor force in each kind of work is indicated in the black columns. The categories of 1900 and 1950 are not directly comparable. They do show, however, such significant changes as the decreasing percentage of workers in agriculture.

duction of mortality rates give us a growing pool of older workers who add greatly to our potential of manpower and experience.

On the other hand, we also have some serious problems. At a time when the school population of the nation is rapidly increasing, due to the rise in the birth rate, we are confronted with a growing shortage of teachers and declining quality in the teaching staff. We face an actual decrease of teachers, because of a shift from this low-paid profession to other occupations, and this threatens a breakdown in the quality of our school system. The evil economic effects of such a decline will be felt 10 to 20 years from now when these young people join the labor force.

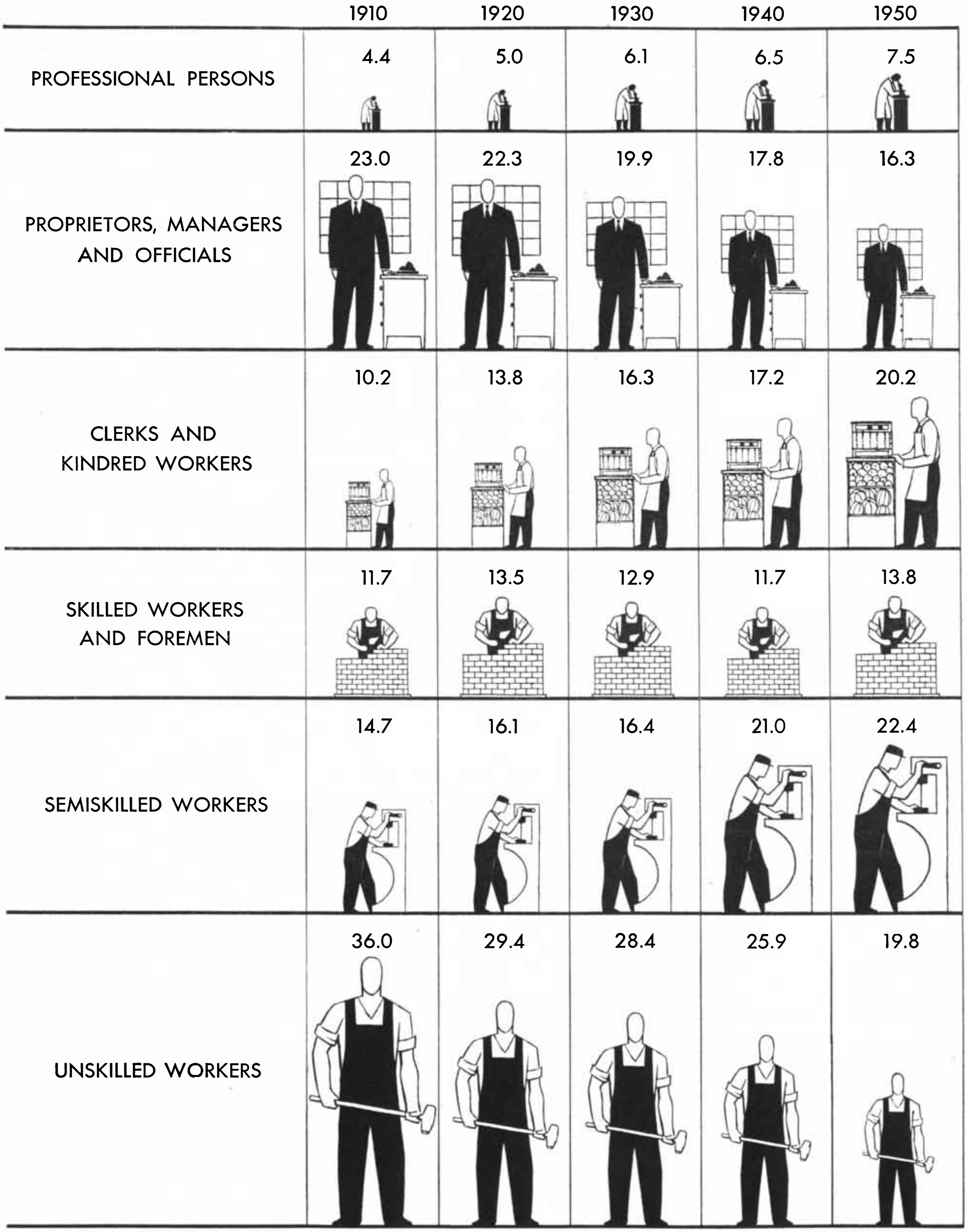
Beyond this, there is the expanding need for skill that our increasingly complex economy imposes on us. Already we are seriously short in some fields, particularly certain professions and skilled trades, in which the necessary manpower cannot be supplied quickly because of the long training required. The demands of our emergency mobilization, both military and civilian, have made this problem acute.

Indeed, it is questionable whether, in the present mobilization or even in total war, it will be possible to expand the labor force again to anywhere near the extent that we did in World War II. Toward the end of the war we had recruited into the labor force an estimated 7.3 million "extra" workers—people who under normal peacetime circumstances would not have been employed in industry at all.

They were, as we have indicated, housewives, youngsters and old people. But in some of these groups we now have smaller reserves to call upon: a higher proportion of the young women are now tied to the home by young children; a larger proportion of the women over 35 are already working at jobs, and a somewhat larger percentage of the older men also are already in the labor force.

OUR major strength, quite clearly, lies in our long-run potentialities. In the last analysis, the power and leadership of the U. S. will rest on the crucial question of whether we can continue to increase our productivity at as high a rate in the future as we have in the past, and this means productivity not only in material goods but also in the services, ideas and educational advance that have made us a rich and great nation.

Ewan Clague, economist, is Commissioner of Labor Statistics, U. S. Department of Labor, Bureau of Labor Statistics.



KINDS OF WORKERS in the labor force have similarly changed. At the left in this diagram are the various kinds of workers. Each vertical column shows the composition of the labor force at the turn of a decade in this century. The number in each box is the percentage of workers in that category in that year; the size of the figures in the boxes corresponds to the numbers. Reflecting the increasing specialization of the labor force is the decrease in the percentage of unskilled workers and the increase in semiskilled workers and professional persons.

INTELLECTUAL RESOURCES

A million and a half Americans work primarily with their brains. The number of young people who are capable of such careers is finite, but we have not yet utilized them fully

by Dael Wolfle

THE scientific and intellectual advances of a nation are generated by a comparatively small number of people. These few—the inventors, scientists, thinkers and scholars who have given us the Declaration of Independence and atomic energy, railroads and radar, antibiotics and masterpieces of music and literature—have contributed to civilization out of all proportion to their numbers. In the U. S. we think immediately of such giants as Thomas Jefferson, Benjamin Franklin, Josiah Willard Gibbs, Thomas Hunt Morgan, Alexander Graham Bell, John Dewey, Mark Twain and Walt Whitman. But the geniuses represent only a part of a nation's intellectual resources; for every genius there are hundreds of less eminent but highly competent men and women who also contribute significantly to the nation's intellectual progress.

The first step in appraising the intellectual resources of the U. S., therefore, is to try to define just what group we are talking about. We cannot define it simply in terms of education, for our intellectual manpower certainly does not include all of the six million college graduates in the U. S. Some of them have retired from work; some are in nonintellectual occupations; some, though they have obtained degrees, can hardly be classed as capable of high-level mental work. Conversely, there are many people making important intellectual contributions who never went to college.

As a rough definition of our intellectual manpower let us say that it comprises all those who work primarily with their brains. We do not know how large this number is, because no exact census of them has ever been taken. Efforts are now being made to do so: the Federal government, professional societies and other agencies have been compiling rosters of specialists in the sciences, humanities and various professions, and the 1950 Census made a number of new tabulations of scientific specialties.

It is estimated that we have about 400,000 engineers, 209,000 doctors, 200,000 college teachers and 175,000 scientists. If we add the architects, editors, lawyers, social scientists and persons in other high-level fields, the total number of brainworkers is perhaps a million and a half. Even if the actual number is twice that, we are still considering only two per cent of the total population and five per cent of the nation's labor force.

Individually the members of this group vary greatly in their intellectual contributions to society. But in general these are the people who have ideas, develop new inventions, processes and products, manage the nation's social, intellectual and administrative machinery, run its industry and commerce and train others for these complex tasks. They are a growing resource. Through their work they have greatly increased the demand for people like themselves. Their scientific discoveries, inventions and social improvements have created new demands for engineers, scientists, social scientists, historians, scholars and other men of ability and training who can manage our ever-more-complex society.

Our problem is: Where are we to find the resources to meet these additional demands? How many people have we who are capable of making creative contributions? How effectively are we discovering and utilizing our intellectual potential? Can we increase our intellectual manpower?

TO ANSWER these questions we must have some reliable measure of intellectual ability. No one will pretend that this can be determined by a simple formula. Intelligence alone is not enough for effective intellectual work: to make creative contributions in a scientific or scholarly field one must also be endowed with interest in it, industry, persistence, strength of character, confidence and some spark of originality.

Twenty-five years ago the U. S. psychologist Catharine Cox Miles made an attempt to estimate the intelligence quotients of 300 of the most eminent men of history. Her estimates were based upon studies of their early writings, school progress and other evidences of achievement in comparison with the records of average children. She concluded that the average I.Q. of these 300 geniuses was above 160, that few fell below 140 and that many were above 180. An I.Q. of 160 is so rare that theoretically only one person in a million ranks that high. But not everyone—in fact, scarcely anyone—who has an I.Q. of 160 goes down in history as a genius; the other traits also are necessary. There are 152 million people in the U. S., but not 152 of the eminence of the group studied by Dr. Miles.

On the other hand, the psychologist Anne Roe recently studied 60 of the most eminent research scientists in the U. S. and found that they varied considerably in intelligence. What the 60 had in common was an intense driving interest in their chosen fields of science. They had become America's most eminent scientists despite the fact that they would not all make the very highest scores on an intelligence test. As for the little-understood gift of creative talent, it is apparently not restricted to geniuses; it exists in lesser amounts in many people—the people who develop short-cuts, who put ingenious new ideas into the suggestion box, who think up improvements on old routines. No one knows for sure, but it is quite possible that creative talent is qualitatively the same sort of thing in such people as in geniuses, the only difference being that the latter have more of it.

If intelligence is not a sufficient condition for creative intellectual work, at least it is a necessary one. Some minimum level of intelligence is necessary to master the basic concepts, problems and techniques of a specialized field. The minimum level varies, of course, with the difficulty of the field. It turns out, for example, that people who go into work in the pure sciences score higher in intelligence tests, on the average, than those in applied fields; within the field of the basic sciences the physical scientists average a little higher than the biologists. Remember, however, that we are speaking only of averages; there are very high I.Q.'s in all fields.

On the whole, we must depend upon intelligence tests, for want of a better measure, as the basis for estimating our potential intellectual resources. Such tests can measure a number of different kinds of ability, but for our general purpose a composite measure of academic aptitude, scored by the method used during World War II for the Army General Classification Test (AGCT), will suffice. The Army scale has an average score of 100 and a standard deviation of 20. These figures are quite arbitrary. They do not mean that the average man answered correctly exactly 100 of the test items. Rather, the raw score of the average man, regardless of what it actually was, was converted to a score of 100 points. Other raw scores were converted to arbitrary scores higher or lower than 100 so that the total distribution had a standard deviation of 20 points (*i.e.,* so that 68 per cent of the population would have scores between 80 and 120).

NOW what do the AGCT scores show as to our intellectual potential and how much of that potential we are actually training for intellectual work? Suppose we take graduation from college as a standard of training for such workers. This is not a perfect criterion, because we need brains in many fields for which college is not always the best preparation, but colleges train most of the high-level specialists, and college graduation will serve as a rough measure of the extent to which we are exploiting our intellectual resources.

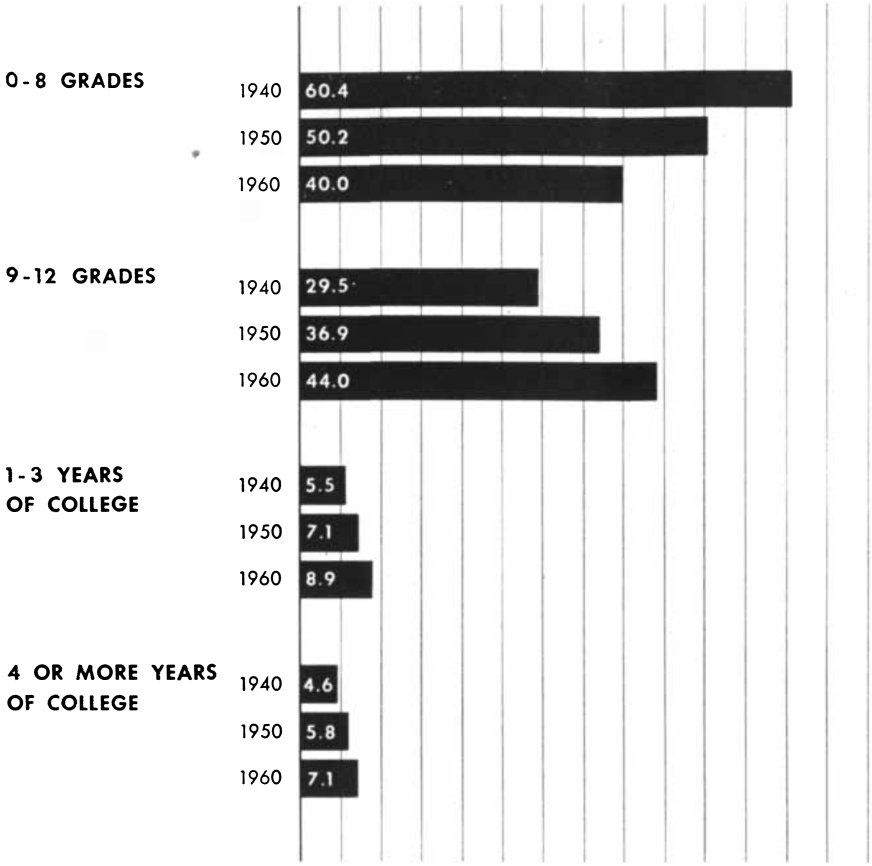
About 10 per cent of the total population in each age group in the U. S. now graduates from college. The median score of these graduates on the AGCT is about 120; that is, half of them score 120 or higher. This means that the youths with an I.Q. of 120 or above who graduate from college represent 5 per cent of the total population in an age group. But in the whole population 16 per cent are at that level of intelligence or above. In other words, of those youths with intelligence equal to or better than that of the median college graduate, only about one in three graduates from college. Actually it would be better to take the score surpassed by three quarters of the college graduates, rather than the median score, as the measure of the ability to do college work. On the AGCT scale this score is 109. About 33 per cent of the total population in an age group exceed this score, but less than a fourth of them go to college and receive a bachelor's degree.

The story is even less favorable when we examine what proportion of able people obtain the Ph.D. degree—today a requirement for many of our top-level intellectual occupations. During the 10 years from 1941 through 1950 U. S. universities conferred an average of about 3,300 Ph.D.'s a year. According to the best available information, the median score of Ph.D.'s on the AGCT is probably in the neighborhood of 134, and the score exceeded by 75 per cent is approximately 123. About 12.5 per cent of the total population scores above 123. Of this group, who possess the intelligence to earn a Ph.D., only about 1.5 per cent actually do so. The proportion will probably increase during the next 10 years; perhaps the figure will be 2 per cent instead of 1.5 per cent. But even so only a fiftieth of the young men and women with AGCT scores over 123 will earn Ph.D.'s.

This is not to imply that everyone with an AGCT score above 109 should graduate from college or that everyone with a score above 123 should get a Ph.D. Bright people are needed in some fields, *e.g.,* in business and the highly skilled crafts, where college training is not necessarily the most effective preparation, and the Ph.D. is not generally needed in such high-level fields as medicine, law, engineering, schoolteaching, business administration or social work. Nonetheless, we have serious shortages of people in many specialties that do require college or Ph.D. training. Consequently we need to give serious attention to the large potential of intellectual resources that we fail to use to full capacity because of lack of the necessary education.

CLEARLY the raw material is available for training more engineers, more scientists, more people in other important fields. Just how many more we might realistically expect is hard to estimate. It is easy to see, however, how the numbers could be increased substantially; we need only look at the reasons why so many bright youngsters fail to go to college.

We could not add greatly to the num-



EDUCATIONAL ATTAINMENT of people over 25 is compared for three decades. The levels of attainment in 1950 and 1960 are estimates. On each bar is the percentage of the population that has gone only as far as that level.

ber of potential intellectual workers by attempting to keep in school those who drop out before finishing high school; the great majority of these drop-outs are only of average or less than average ability. It is at the point of high-school graduation that the biggest single loss of bright students occurs. Only a third of the high-school graduates enter college, and of the two-thirds who do not, a large proportion are above average in ability. The attrition among bright students continues in college, for half of the people who enter fail to graduate. Most of the drop-outs, to be sure, are in the lower-ability brackets, but many are brilliant students; even among that rare company who score above 150 on the AGCT more than 20 per cent leave college before graduating.

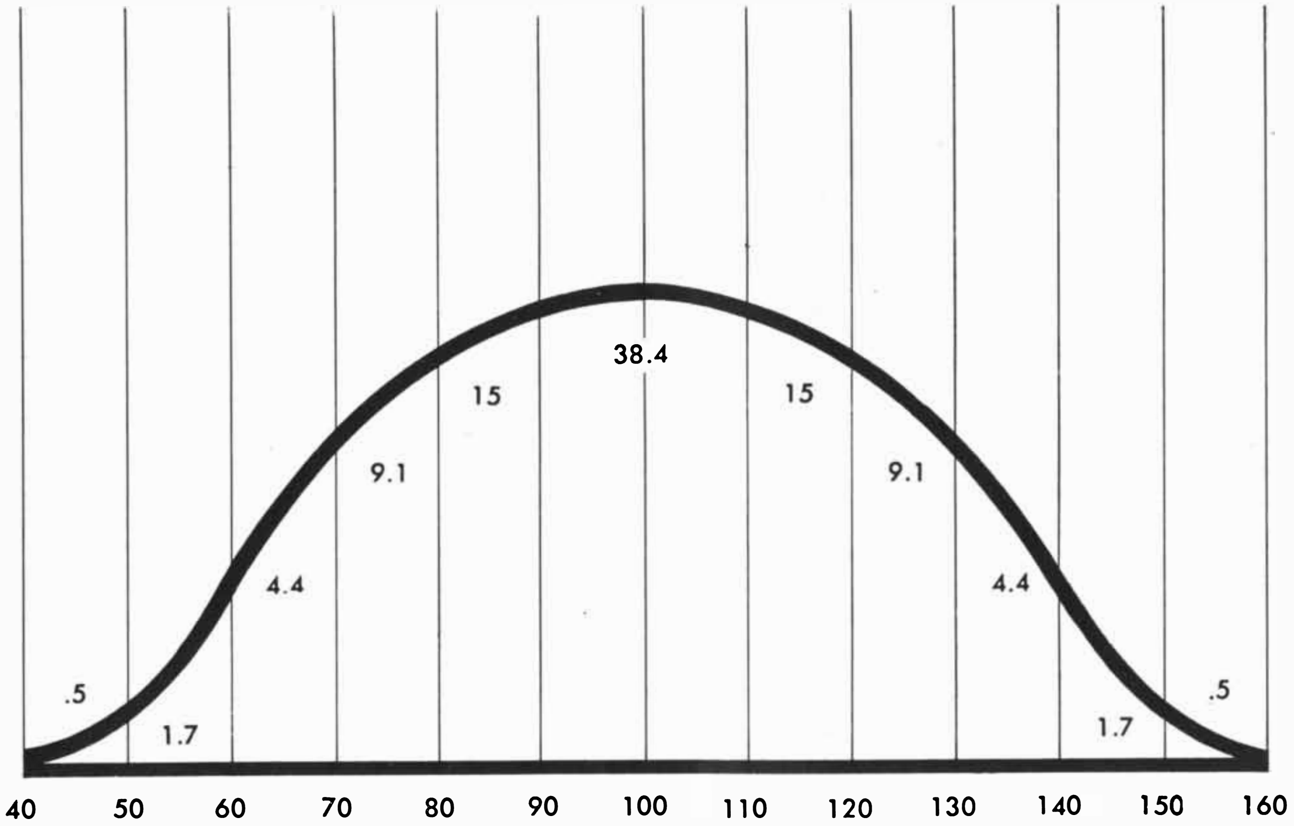
There are two main reasons why bright students fail to go to college or quit before graduation if they do go: lack of interest and lack of money. Of these, lack of interest is the more common one. A great many able students forego college because their parents do not expect them to go, because they decide early on a vocation that does not require college, because they prefer to marry or because their friends are not planning to go to college.

If the country wants to use the abilities of its ablest youngsters at the highest possible level, it must somehow encourage more of them to go on with their education. The first step, of course, is to identify these best brains. Fortunately this is not too difficult. The people who possess the talent for academic work and scholarship of a high order can be picked out at a fairly early age. Dr. Cox pointed out that the eminent people she studied gave evidence of their unusually high I.Q.'s in early childhood. Voltaire wrote verses "from his cradle." Coleridge could read a chapter from the Bible at the age of 3. Mozart composed a minuet at 5. Goethe produced grown-up literary work at 8. Nowadays intelligence-test scores and school-achievement records make possible reliable early selection of the able children. Indeed, whether a youngster will be successful in college can be predicted about as well by tests given at the ninth-grade level as at the time of college admission.

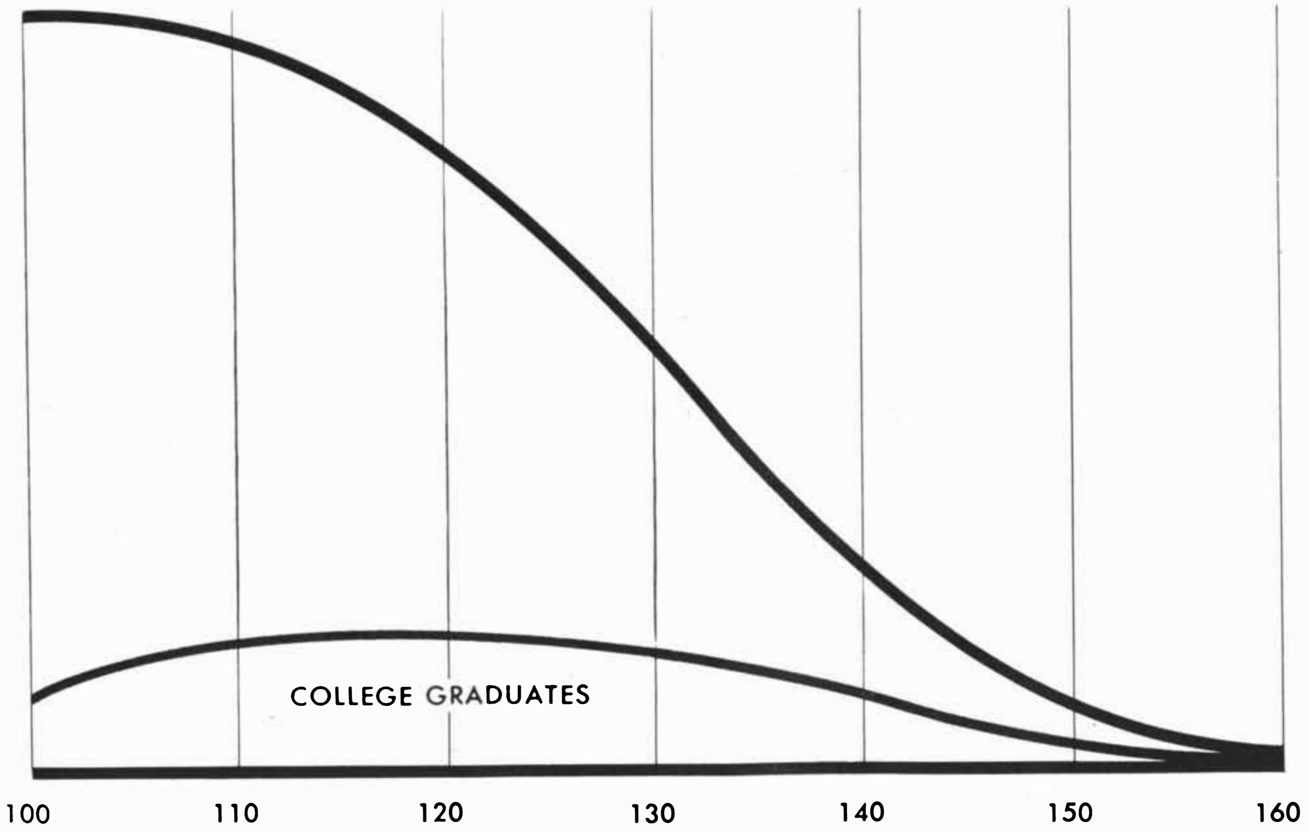
The next step is to give active encouragement to those who show the greatest promise. In some cases it is necessary to offer financial help. At the highest levels of training considerable help is becoming available. The Federal government, concerned about shortages of scientists and engineers, has started several new scholarship programs. The Atomic Energy Commission grants fellowships to graduate students in the sciences related to atomic developments. The Veterans Administration gives subsidies to college graduates interested in careers in clinical psychology. The new National Science Foundation plans to make a scholarship and fellowship program one of its chief activities. But I suspect that graduate fellowship programs will be less effective in increasing our intellectual manpower than their supporters hope. To qualify for a fellowship one must first finish college. If the goal is to enlarge the total pool of highly trained talents, money offered as scholarships to help bright youngsters start to college would probably be more effective than fellowships awarded to graduate students. There is no doubt that we need a great many more scholarships at the undergraduate level.

WE have an even greater need, however, to improve our efforts to interest the brightest youngsters in pursuing an advanced education. In this task our schools frequently fall down. Despite the widespread school use of intelligence tests, too frequently the results are not used as a basis for encouraging the most promising. More school systems should follow the example of that in the State of Iowa. Each Iowa child is given the Iowa Test of Educational Development at several points during his school career. The most promising are actively encouraged by their teachers to continue their education, and their parents are notified of their promise. The Iowa psychologist Leo Phearman found that 92 per cent of the Iowa high-school seniors who scored in the top 2 per cent on these tests, and 75 per cent of those in the top 10 per cent, continued their educational careers into college.

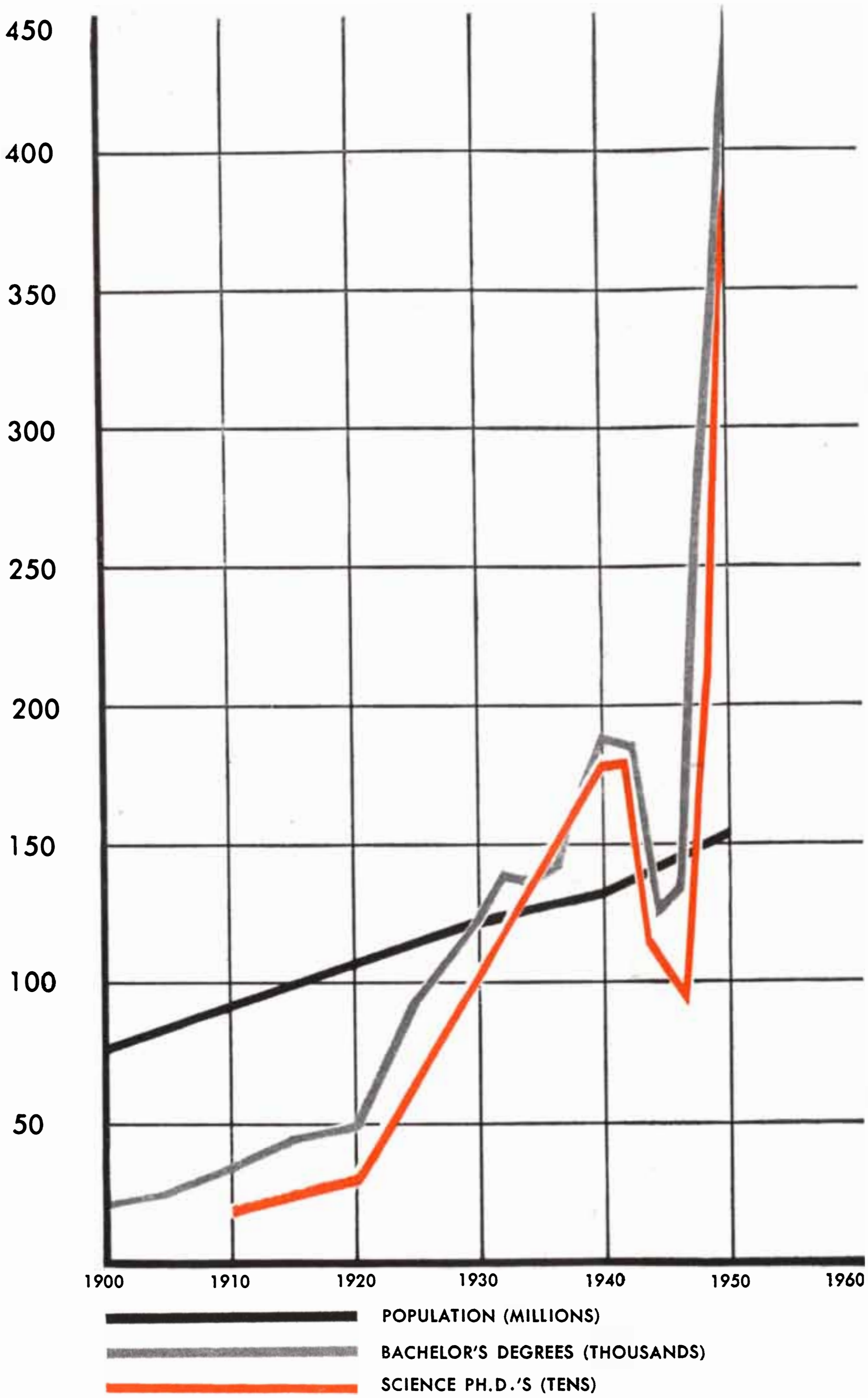
Probably one of the reasons why so many bright students lack interest in going on to higher education is the poverty of stimulation in the school program to which they have been exposed. Elementary and secondary schools all over the country have gone in for "how-to-study" courses, remedial reading, sight-saving classes, opportunity rooms and other commendable special provisions for the handicapped and the slow, but very few devote as much effort to special handling of their most brilliant students. One of the outstanding exceptions is the Bronx High School of Science in New York. This school each year selects a freshman class high in ability and eager for scientific careers. It then gives these students a high-school training and experience so effective that practically all of them graduate from high school and practically all of the graduates go to college. A widely influential effort to encourage bright students is the annual Westinghouse Science Talent Search. The Jackson Memorial Laboratory in Maine each summer uses as research assistants a small selected group of high-school stu-



DISTRIBUTION OF INTELLIGENCE in the population is shown by a curve based on the scores compiled by those who took the Army General Classification Test. The numbers at the bottom of this diagram represent the scores of the test; the numbers closer to the curve show the percentage of people who made a score in that range.



DISTRIBUTION OF COLLEGE GRADUATES on the AGCT scale is shown by the curve near the bottom of this diagram. The curve that begins at the upper left is a section of that at the top of the page. The area between the two curves approximates the proportion of people of better-than-average intelligence who do not go to college.



BACHELOR'S DEGREES AND SCIENCE PH.D.'S have increased in number at a rate greater than that of the increase in the total population. The wartime dip in such degrees has been corrected by the postwar rise.

dents who show interest and outstanding promise in biology. This approach—giving young students an opportunity to engage in research—seems to be an effective method of starting people on careers in science or scholarship.

The colleges themselves could do a good deal more to promote the development of superior students. One change that would cost little or nothing and would probably have good results would be to let the brightest students go ahead at their own pace. Youngsters of high I.Q.'s are capable of very rapid learning and early productive contributions. The Ohio psychologist Harvey Lehman, who has made a special study of this subject, cites many examples of great achievements by young thinkers. The grain binder was invented by John F. Appleby at the age of 18. Jane Austen finished *Pride and Prejudice* when she was 21. Louis Braille, blind since the age of 3, developed the Braille alphabet at 20. William Cullen Bryant wrote *Thanatopsis* at 18. Samuel Colt was 16 when he conceived the idea of the revolver. Sir Humphry Davy was 20 when he discovered the anesthetic properties of nitrous oxide gas. Galileo at 17 discovered the isochronism of the pendulum. Marconi was 21 when he transmitted the first radio signals. The first synthetic dye was discovered by William Henry Perkin at 18. Lord Kelvin had established a reputation in mathematical physics by the time he was 21 years old. And in general, according to Lehman's study, the great scientists and scholars who contributed the most in total creative output were the ones who started earliest.

We can find similar examples of early achievement in the current crop of youngsters in this country. An important new method for releasing archaeological specimens from the limestone in which they are imbedded was developed just this year by a 21-year-old college student. An 18-year-old student at the University of Minnesota holds several patents on electronic equipment and serves as a consultant to a large electronic manufacturing company. One of the stellar contributors to the Los Alamos project during the war was a youth not old enough to vote.

No one knows how much is lost to science and creative scholarship by holding brilliant youngsters back to the pedestrian pace of the typical school and college. They can develop faster. As S. L. Pressey has effectively demonstrated at Ohio State University, they can do so without damage to health, without appreciable loss of opportunity to participate in extracurricular activities, without loss in quality of work and with the very positive benefit that a larger percentage of these accelerated students graduate from college than is true of equally bright but non-accelerated students. They can start graduate work earlier and can begin contributing sooner to society and to their chosen fields of work.

FROM every standpoint it is clear that we are not exploiting the intellectual resources of the U. S. to anywhere near their full potential. We can have more engineers, more scientists, more doctors, more scholars and more specialists of all types if we need them. To obtain them, however, we must do better than we have done in the past to identify the brightest youngsters, encourage them to plan on higher education, offer them a chance to work in their chosen fields, give them financial assistance when necessary and give them the kind of education that will allow them to go ahead rapidly to take their places among America's intellectual leaders.

Dael Wolfle, psychologist, is Director of the Commission on Human Resources and Advanced Training.

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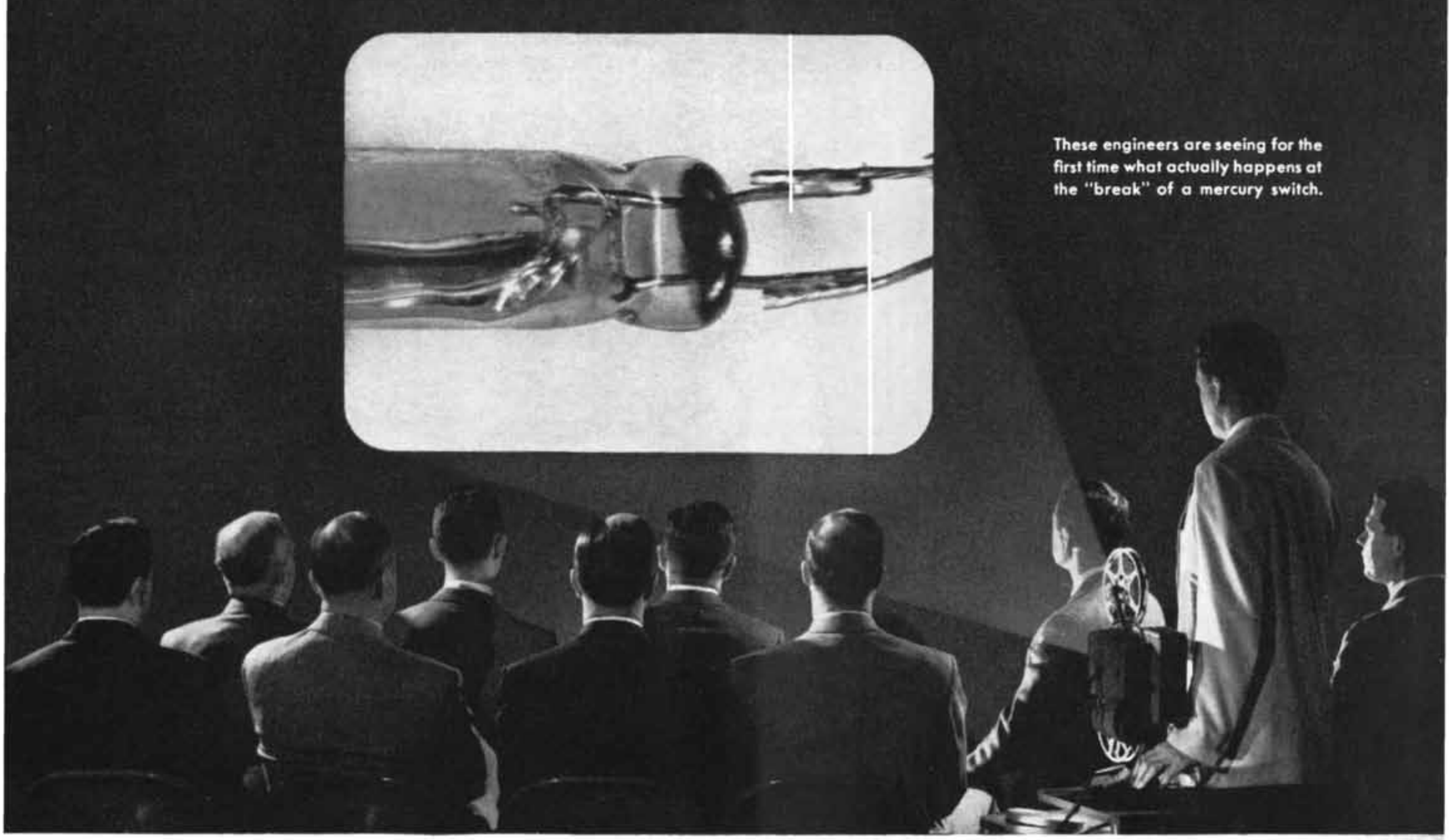
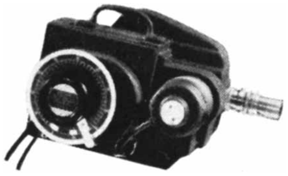
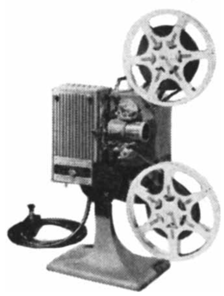


These engineers are seeing for the first time what actually happens at the "break" of a mercury switch.



The Kodak High Speed Camera can now be supplied with a special feature which permits the recording of cathode-ray oscillograph traces through the back of the film. This makes possible high speed motion pictures of mechanical action with its electrical aspects simultaneously superimposed *on the same 16mm film.* When projected at normal speed, you get a complete picture of combined mechanical and electrical action slowed down as much as 200 times.

This basic improvement has countless new applications for solving design, production, and product performance problems through high speed movies, particularly those involving electrical equipment. Since an argon lamp times the film travel, extremely accurate analysis is possible. This unique tool may be the answer for which you have been looking. Further information and a copy of the booklet "Magnifying Time" will gladly be sent on request.



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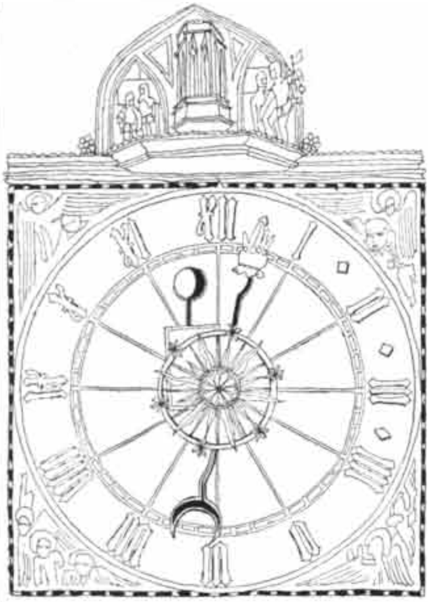

SCIENCE AND

Students and the Draft

THE drop in college enrollment this fall apparently will not be as great as was predicted last spring. The U. S. Office of Education now expects a student body of 2,045,000, a decline of about 9 per cent from last year's enrollments instead of the expected 20 per cent. The decline is due not to the draft but to the subsidence of the postwar G.I. bulge in enrollments and to the fact that the freshman class this fall reflects the severe depression drop in the birth rate of 18 years ago.

The Selective Service regulation that no youths under 19 shall be drafted until all available older men have been taken has effectively preserved the freshman class from the draft. The loss through voluntary enlistments of high-school graduates will probably be more than made up by the gain of those who otherwise might not have gone to college but who will do so in the hope of gaining draft deferment. So far as upperclassmen are concerned, most draft boards have complied with the policy of Selective Service headquarters and granted deferments over the summer, until the college aptitude tests administered a few months ago could be graded and reported to the boards. This deferment was encouraged by the low national draft quotas set during the summer—15,000 in July and 22,000 in August. By the time all the test scores were in, the fall term was only a month off, and once the new term begins Selective Service policy is to defer all students, regardless of their grades, until the end of the school year. As a result, though some students have been and are being drafted, the colleges' fear of severe losses has been allayed for at least a year.

An indication of the results of the deferment tests was given by the scores of the first of the four tests, that of May 26. About 63,000, or 38 per cent of those taking the test, failed to get the passing mark of 70. Those who either passed the test or rank high enough in their classes are to be considered for deferment. This policy is not binding on the local boards, but they are expected generally to follow it so long as they have no difficulty in filling their quotas from other sources.

It has been made clear to students that deferment does not mean exemption. Colonel Candler Cobb, New York City Selective Service director, said: "The student and his family must make up their minds whether the man is to go to the armed forces now or later." Under Selective Service any man who is in a deferred classification when he reaches 26—ordinarily the top age limit for the draft—remains liable to call until he reaches the age of 35.

The effect of this on the supply of new engineers has been estimated by the Office of Education. The number of engineering graduates will drop from 38,000 this year to 17,000 by 1954. At the same time, as the number of veterans in engineering schools diminishes, the proportion of graduates who are liable for military service will rise from 50 to 80 per cent. Those getting "essential" jobs within 30 days may receive occupational deferment. On the whole, however, it is estimated that only 3,000 of the 17,000 graduates in 1954 will be available to industry, whereas industrial employers report that they need 60,000 additional engineers now and will probably require a continuing supply of at least 30,000 each year.

New G.I. Bill?

THE educational provisions of the G.I. Bill of Rights—under which 500,000 veterans took courses in engineering, 250,000 took courses in teaching and 200,000 took courses in medicine—expired for most veterans on July 25. Even before the books were closed on that great educational venture, Washington had begun to discuss a new G.I. bill for the veterans of Korea.

About 50 G.I. education measures have been introduced in Congress, many of them calling for the same rights as those given to World War II veterans. None of these is likely to receive serious consideration. It appears that the benefits to be allowed this time will be more limited. The two most strongly supported proposals are those of the Administration and of Representative Olin E. Teague's Select Committee studying veterans' training.

The Administration proposal, introduced in the Senate by Robert S. Kerr of Oklahoma and Walter F. George of Georgia, extends the educational provisions of the present act with two main changes: 1) the Government would pay only half the veteran's tuition; 2) those who were 23 or under on June 27, 1950, or on the day they entered service, or whose education was interrupted by the draft, would be entitled to benefits for a period equal to their length of service up to 48 months; those over 23 whose education was not interrupted by the draft would be entitled to only one year of such training. Under the old bill, all eligible veterans were entitled to full tuition for a period equal to their length of wartime service plus one year, up to a total of four years.

The Administration bill S. 1940 also would restrict scholarships in privately owned schools to those in which at least 25 students or a third of the student body pay their own tuition. This provision is intended to discourage the mushrooming of veterans' training schools such as appeared after the last war.

Representative Teague's committee has indicated that its plan will be to offer less money to more people. Under S. 1940 a limited number of veterans might be entitled to up to four years of education; the Select Committee, on the other hand, apparently will advocate fewer years of education for more veterans. The Committee will also propose that payments be made directly to the student instead of to the school, the intention being to provide a scholarship system rather than a Government subsidy for schools.

Shortage and Surplus

THOUGH military spending has passed $35 billion a year and is still increasing, the U. S. Department of Labor in its July survey of the labor market reported that "defense activities were not a dominant force in local labor markets except in a few areas." The national labor market picture was spotty, with shortages of workers in a few areas and unemployment in others.

The shortages were most acute in aircraft centers like Hartford, Conn., Wichita, Kan., Indianapolis, Ind., and San Diego, Calif., and at the huge atomic construction sites near Augusta, Ga., and Paducah, Ky. The machine-tool and metal-working industries also were suffering severe nation-wide shortages of skilled workers, and the shortage of engineers and many kinds of scientists had reached the proportions of a crisis.

The other side of the picture was to be found in many peacetime industries.

One problem in "less essential" industries was layoffs because of materials shortages. Said the Department of Labor survey: "Hardest hit were the major automotive, refrigerator, and radio-TV centers, among them such important areas as Detroit and Chicago." In addition, "softened demand for some lines of consumer goods—particularly in radio-TV, furniture, and to a lesser extent, textiles, apparel and shoes—produced an upsurge of joblessness in a number of areas." Most of these were in highly industrialized sections of the Northeast, including New England's textile, shoe and jewelry centers, New York's garment industry, railroad shops and mining towns in Pennsylvania's coal country, and auto towns in Michigan, Ohio and Indiana. Out of 165 labor market areas in the nation, 6 were considered to have a labor shortage, 63 to be in balance, and 96 to have moderate to substantial surpluses.

Said the survey: "Evidence that the manpower pinch has not yet been fully felt by the Nation's employers is reflected in the failure to generally relax hiring specifications. Specifications with regard to age, sex, race, training, and experience vary widely. For the most part, there has been no general hiring of women in what are normally considered men's jobs. In only a few areas was there evidence that anything like the elaborate training programs evolved during World War II were contemplated."

The situation among Negro workers was a subject of special interest, since these workers are regarded as an important manpower reserve. The Urban League's Industrial Director, Julius A. Thomas, said that unemployment among Negroes was still proportionately 20 to 40 per cent higher than among whites in most centers. The Urban League protested to President Truman against discrimination by the Atomic Energy Commission and its contractors at Oak Ridge, Tenn., Hanford, Wash., and the new centers in the South where units in the H-bomb project are under construction. Said the League's statement: "At Oak Ridge Negro workers are restricted to unskilled and service occupations. Living accommodations for Negroes are completely segregated from the main project area. On the Paducah project efforts to assure the employment of Negroes in production jobs have been unavailing up to the date of this report. At the Savannah River project, Negro women workers have been employed only as maids. Negro building mechanics have not been employed."

AEC Report

THE Atomic Energy Commission's Tenth Semiannual Report, issued last month, announced continued progress in the expansion of the atomic weapons program. States the Report: "Construction and equipment accounted for nearly three-fourths of the more than $2,000,000,000 appropriated for fiscal year 1951. Work progressed at the two new major production plants in South Carolina and Kentucky. Construction of a number of other facilities proceeded at an accelerated pace." The U. S. this year overtook Canada in the production of uranium ore, and now ranks second only to the Belgian Congo as a supplier of raw materials for the bomb program. President Truman asked Congress for an extra $233 million, in addition to the AEC's regular 1952 appropriation of $1,200 million, for new plants and equipment "made necessary by recent accelerated technical developments."

On the non-weapon activity of the Commission, the Report announced continued progress on reactors to propel submarines and airplanes. The experimental breeder reactor at Arco, Idaho, the first reactor designed to produce more fissionable fuel than it consumes, is now being tested, though it will be some time before specific information on breeding is obtained. This reactor will also eventually be used to study the possibility of simultaneously producing fuel and power, one of the most promising approaches to the industrial utilization of atomic energy.

Among the research results announced in the Report is the solidification of helium 3 at the Argonne National Laboratory. Like the common isotope helium 4, helium 3 cannot be frozen except under pressure. It was found that even at absolute zero a pressure of 400 pounds per square inch would be needed to solidify it.

The AEC's program for increased cooperation with private industry has continued to advance. Among the latest developments:

1. Twenty-eight scientists from four industrial groups visited Oak Ridge to begin a year's study of the possibilities of private nuclear power production.

2. Abbott Laboratories acquired private facilities in Oak Ridge to process radioactive isotopes for medical use. One reason for the move is the increasing medical interest in radioactive gold for the treatment of inoperable chest tumors. The half-life of this isotope is only 2.7 days, so pharmaceutical processing at the point of production is necessary to speed it to the user. This plant is the first independent commercial activity directly related to atomic energy which has been located in an AEC community.

3. Brookhaven National Laboratory has made two 1,000-curie sources of gamma rays available to industrial scientists for irradiation of samples. The two Brookhaven sources, made of cobalt 60 or tantalum 182, are each as powerful as 2.2 pounds of radium, more than existed in the whole world before World War II.

The AEC has also announced that all the isotopes now available on an unre-

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   Study of physical and chemical structure of plates as related to performance.
   Study of chemical reactions occurring during charge and discharge.
4. Rubber and Allied Products.
   Study of chemical reactions taking place during vulcanization and other processing.
5. Furnishes a scientific method of classifying and studying variations in cotton, silk, wool, and other natural and synthetic fibers.

Applications in Mineralogy

1. Study of Soil Chemistry.
2. Identification, classification, and differentiation of genuine, both natural and synthetic, and imitation gems by a non-destructive test.
3. Correlation of variation of clay structure with catalytic activity in oil refinement, etc.

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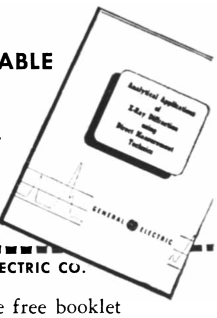

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stricted basis to U. S. buyers will be made available to foreign customers. This raises the number of AEC isotopes available to foreign purchasers from 26 to 99. Hydrogen 3, or tritium, will not be exported.

Endocrine Arteries

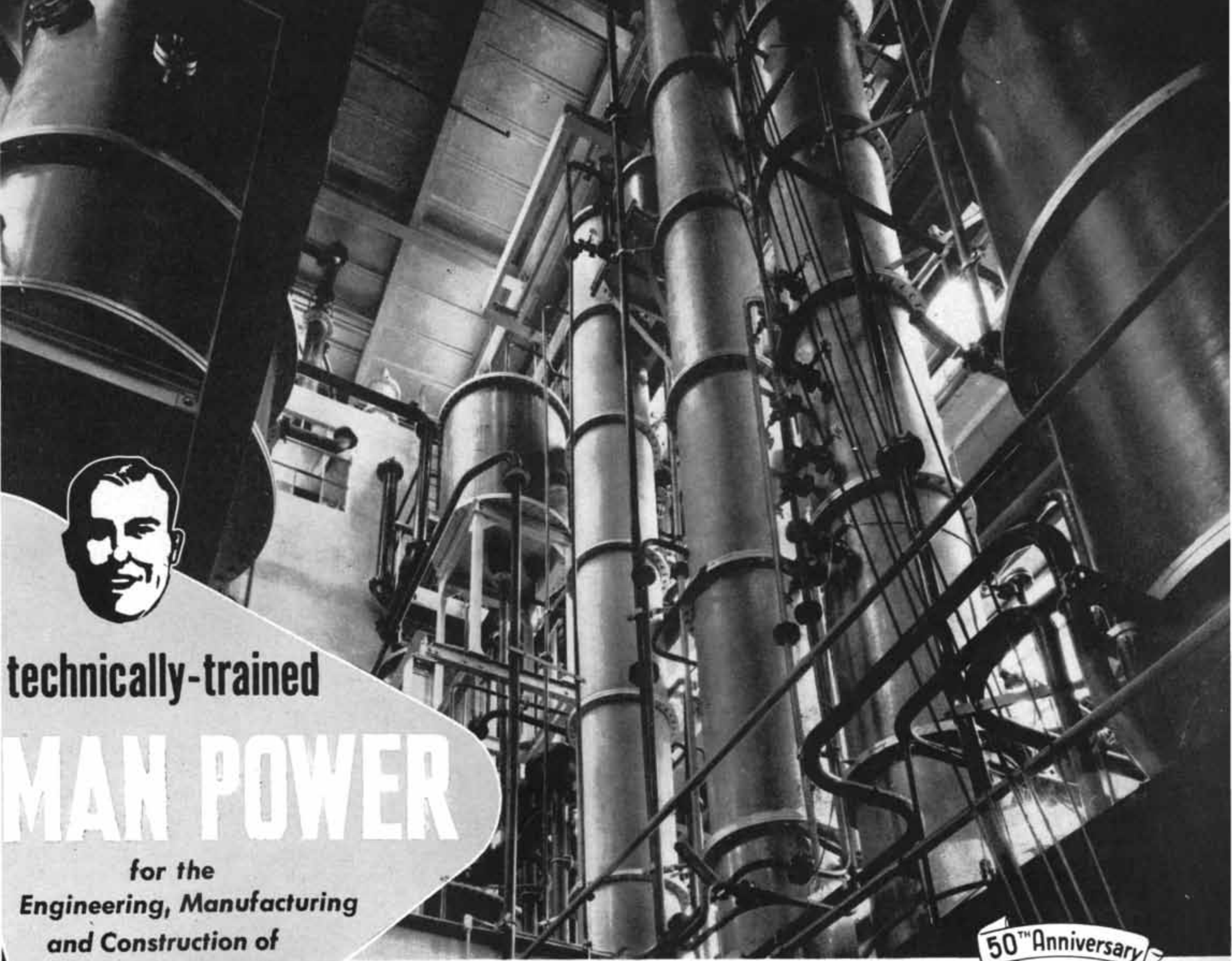
ARTERIES are not just tubes for carrying blood; they are organs that take part in the synthesis and breakdown of substances in the bloodstream. This discovery has been made by a group of workers at the University of California, who have found that arterial tissue can synthesize cholesterol, the substance responsible for hardening of the arteries.

Cholesterol is an important biochemical intermediate. It is manufactured in the skin as a step in the production of vitamin D. It is also present in many foods. It has been believed that such dietary cholesterol was to blame for atherosclerosis, a circulatory disease in which cholesterol is deposited on the inside of the arteries, reducing the circulation of the blood and sometimes causing apoplexy or heart failure by cutting off the blood supply to the brain or the heart. This was the theory that was being checked by M. D. Siperstein, I. L. Chaikoff and S. S. Chernick of the University of California School of Medicine. They put bits of rabbit and chicken arterial tissue into a nutrient solution and added to it acetate labeled with radioactive carbon atoms. Within three hours cholesterol containing radioactive carbon could be found in the solution. While the production of cholesterol was small, only about a tenth as much as for an equal weight of liver tissue, it was consistent. Considering the great surface of arterial tissues in the body, it could play a very important role in the causation of atherosclerosis.

Photosynthesis Without Cells

IT is an accepted principle of plant physiology that photosynthesis can take place only in intact green cells. This belief, based on the failure of almost 75 years of effort to reproduce photosynthesis outside the cell, has now been disproved by Daniel I. Arnon of the University of California, who has succeeded in using a combination of leaf extracts to develop a photosynthetic reaction.

Arnon achieved his feat by combining two previously known biochemical reactions. In the first of these, discovered by R. Hill of Cambridge University in 1937, chloroplasts, the chlorophyll-bearing bodies of green cells, in the presence of light remove hydrogen from water and liberate oxygen. But to complete the photosynthetic reaction it is necessary for the hydrogen to reduce carbon dioxide, resulting in the fixation of carbon. This can be accomplished by a "malic" enzyme which has been iso-



lated from animal tissues and is known to exist in plants. Arnon succeeded in concentrating this substance in cytoplasmic fluid extracted from sugar beet and sunflower leaves. Then, by combining this extract with an extract of chloroplasts, he succeeded in producing a complete photosynthetic reaction outside the cell—the reductive fixation of carbon dioxide and the release of oxygen in the presence of light. It is notable, says Arnon, that all the components of his reaction are present in living green leaves.

Another new result in photosynthesis research has been presented by Bernard L. Strehler and William Arnold of the Oak Ridge National Laboratory. They found that plants not only absorb light; they can also emit it. Five different types of green plant were exposed to artificial light. When the light was turned off, the plants themselves emitted light for as long as two minutes. The light produced by the plants was of very low intensity, requiring special electronic equipment for its detection. Strehler and Arnold think the most probable explanation is that part of the light energy absorbed by the photosynthesis reaction is released by a reversal of the reaction, with chemical energy being turned back into radiant energy.

Portable Blood Separator

BLOOD can be split up into its most useful components as soon as it comes out of the donor's arm in a new portable fractionator developed by engineers of the American Optical Company. Plasma, red cells and platelets are available even before the donor gets off the cot. Separation is done by ion-exchange resins and an automatically controlled centrifuge. The device, which so far has been made only in one pilot model, when generally available will make blood fractions much more accessible, especially in areas of the world that now have no facilities for blood storage or fractionation. It will also make it possible to study abnormal blood more easily. The completely automatic separation will greatly reduce the danger to medical workers of handling infected blood.

The machine was designed by Charles A. Ellis, Robert Tinch and Douglas M. Surgenov of American Optical and Harvard University. The firm has now been asked to make machines that will separate the entire list of blood products automatically under sterile conditions.

Technetium in the Sun

ELEMENT 43, technetium, which is so rare that it had never been isolated until it was created artificially in the cyclotron, has been detected in the sun's spectrum. Charlotte E. Moore of the National Bureau of Standards reached this conclusion by comparing the recently described spectrum of the

element with that of the sun. Of the six outstanding lines in technetium's spectrum, three are in a region where the solar spectrum is unknown. Of the other three, two, if present in the sun, would be masked by the stronger lines of more abundant elements; the third agrees with a hitherto unidentified line in the solar spectrum.

If there is any technetium in the sun, it is very rare. But according to present information about the element, it is surprising that there should be any at all. The longest-lived known isotope of technetium has a half-life of only about 212,000 years; at that rate, any that was present in the sun when it formed would have decayed long ago. Dr. Moore suggests that if her identification of the element is correct, there must either be a much longer-lived isotope, or else technetium may be continually created in the sun by neutron bombardment of molybdenum, the same process by which it is created in the cyclotron and the nuclear reactor. In either case, it would seem that technetium may not be so extremely rare in the earth's crust as has been thought.

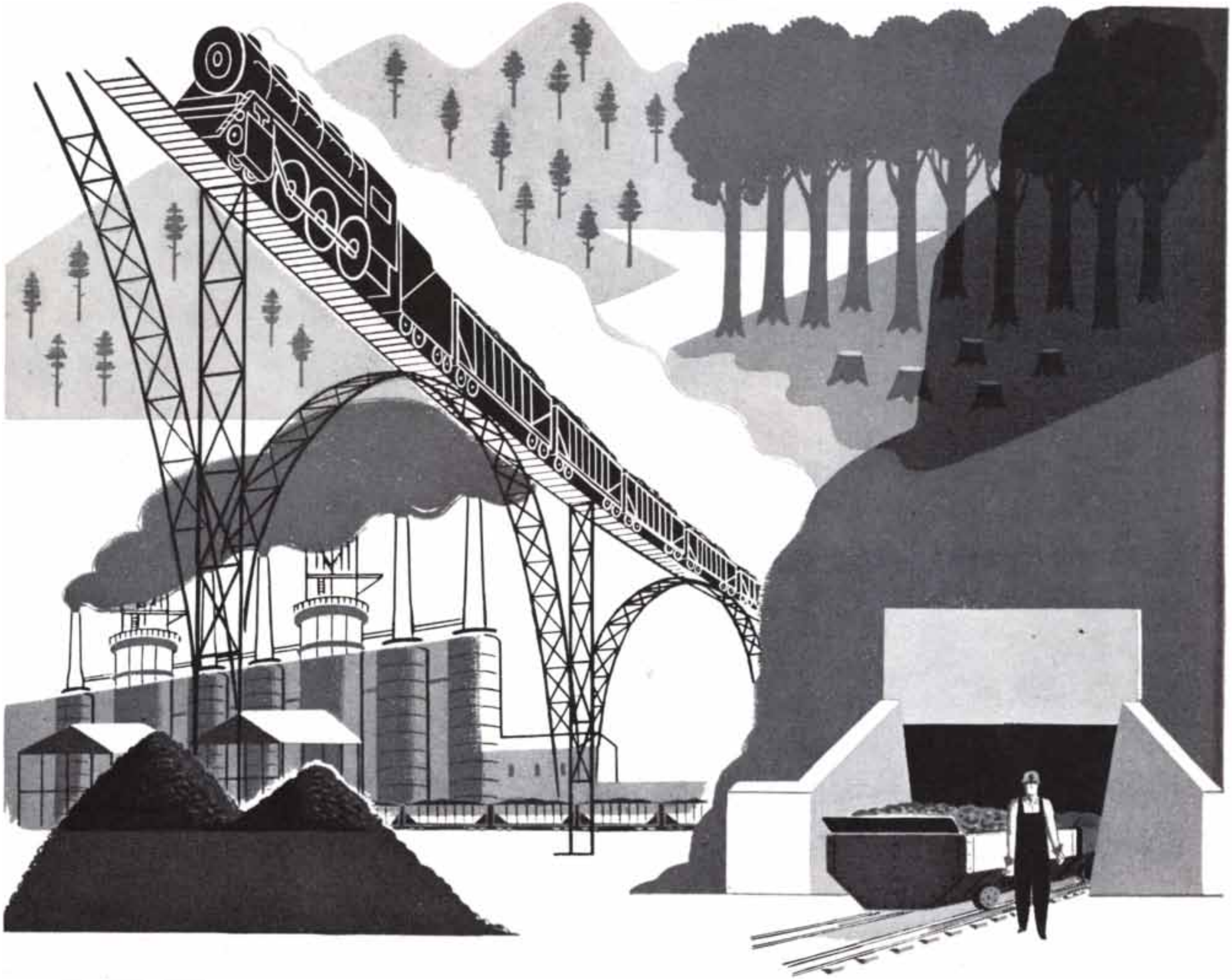
How Salmon Get Home

An explanation of one of the most engaging phenomena of nature—the salmon's return from hundreds of miles at sea to its native creek—has been proposed by Arthur Hasler and Warren Wisby of the University of Wisconsin. They believe that the fish can smell its way back home.

To determine the sensitivity of a salmon's smell Hasler and Wisby built special aquariums in which the water could be changed to introduce different odors. When water from one stream came into the aquarium, the fish were fed; when water from a second stream came in, any fish swimming into the feeding area received an electric shock. Baby salmon quickly learned to tell the two streams apart, and remembered the difference long after the shocks were stopped.

"It appears," say Hasler and Wisby, "that substances in the water, probably coming from the vegetation and soils in the area through which the stream runs, give each stream an odor which salmon can smell, remember, and recognize even after a long period of non-exposure."

If their theory is correct, it may have an important application. The damming of many Pacific Coast salmon streams is resulting in a progressive decline of the yearly catch, as huge numbers of salmon batter themselves to death trying to get over the dams and back home. Devices such as "fish ladders," which are supposed to help the salmon over the dam, have not been particularly successful. According to Hasler and Wisby, it should be possible to condition salmon



fry to the odor of a different stream, so that after their years of growth at sea they would return to spawn not in their birthplace but in a different, unobstructed stream.

Sickle Cells in Whites

SICKLE-CELL anemia, a hereditary blood disease in which many of the red corpuscles become sickle-shaped and ineffective as oxygen-carriers, is the only disease or physical impairment for which there has been evidence of an association with Negro parentage. Because the great majority of the cases known in the U. S., where the disease was discovered, have been in Negroes, it has been widely believed that the disease is confined to them. Now two unrelated investigations have disclosed communities of white people with no evidence of Negro ancestry and a high proportion of sickle-cell disease.

In one investigation, described in *Nature*, F. Dreyfuss and M. Benyesch of Jerusalem report 12 cases of sickle-cell anemia among Yemenite Jews now in Israel. They note that these patients "neither bear any resemblance to Negroes nor is heavy admixture of Negro blood at all probable." The other investigation was made in a group of villages around Lake Copais in Greece. Four Athens physicians report in *The Lancet* that 15 children, 25 per cent of the population, suffered from the disease, compared with about .2 per cent of U. S. Negroes.

The Greek investigators note that "so great a number of cases of sickle-cell anemia among whites in a small area has never been described before, and raises several questions." In particular, noting the other ailments common in the villages they were studying, they ask: "Are malaria and chronic undernourishment etiological factors in this disease?"

The Automatic Factory

WITH the great development of automatic controls during and since the war, there has been much speculation on the possibilities of the automatic factory, where all steps from the raw material to the finished product would be done by automatically controlled machines. A careful investigation of this problem has been made by a group of students at the Harvard Business School. They conclude that there is nothing to prevent most manufacturing industries from being made fully automatic, and to prove it they themselves have designed an automatic piston factory.

The group of eight students, led by John T. Diebold, reports: "To a large degree man's function in today's industry is the tending of machines. Basically the machine performs the desired fabricating operations while the man services or

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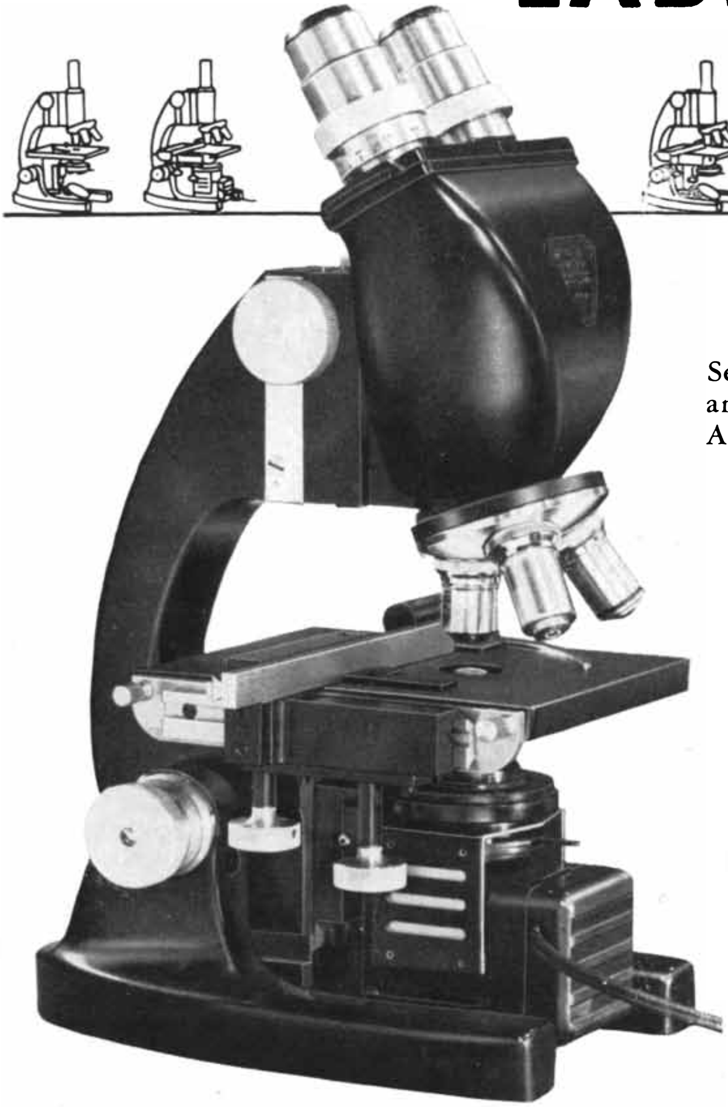

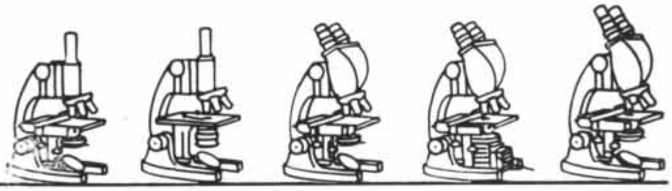

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tends the machine." If these functions are performed by automatic controls, "a higher rate of output can be made possible with no increase, and perhaps a decrease in the capital requirements." They argue that automatic control is just as feasible in those industries that manufacture discrete units as in such continuous-process industries as petroleum refining, where automatic controls are already used to a great extent. The solution for most industries, they believe, is not the single, highly specialized machine that does the whole job by itself, as for instance in many food packaging plants. Such a system can justify itself economically only where a great many units are to be produced with no change in the product. A better alternative in most cases is "the utilization of standard production type machines for the fabricating function, and the linking together of these units with automatic materials handling equipment for the achievement of automation. An over-all system of control can be provided by use of a small digital computer."

They conclude: "The technology required for industrial automation is in large part already here. The lack of knowledge of what is technologically possible, and the lack of fruitful thinking about the industrial application of this technology is today the greatest single factor that is holding back the level of automation which is otherwise possible."

Corn Seed Bank

THE widespread cultivation of hybrid corn has been an immense advance in American agriculture, but it carries with it certain dangers. The universal use of hybrid corn seed could result in the disappearance of the open-pollinated varieties from which all inbred strains are derived. As Paul C. Mangelsdorf wrote in his article "Hybrid Corn" [SCIENTIFIC AMERICAN, August]: "The loss of the original source of breeding material would mean not only that improvement of the present strains would be restricted but that new types of hybrid corn could not be developed to cope with new diseases or insect pests suddenly become rampant."

To meet this danger, the U. S. Department of Agriculture has inaugurated a seed bank to maintain a permanent collection of all the varieties of corn native to the Western Hemisphere. The program will be executed by the National Research Council. Seeds of over 2,000 varieties will be collected, classified, kept in cold storage and replanted often enough to maintain a viable stock. The bank will serve as a reservoir of hereditary qualities which can be used by corn breeders throughout the hemisphere. Many types of corn will become available to breeders for the first time through the new bank.

Have you a "little" million dollar opportunity like this?

This is how a saving of a few mils on a lamp base can be multiplied by 830,000,000—the average number of incandescent lamps sold each year.

Engineers of two major lamp manufacturers had looked hard at the price advantage of aluminum over brass. A difference that made them agree with our suggestion, "It might cost less to make lamp bases of aluminum."

"Might cost less, but will the bases be as good?" they asked . . . "Will aluminum change our way of making lamp bases?"

Together we started two long-range projects. One to test aluminum alloys in weather, industrial fumes and years of standing idle that lamps endure. The other to find one of these alloys that could take the punishment of five progressive draws and a thread rolling operation; one with a high melting point to withstand the temperature of the red-hot glass that's poured into bases to insulate them.

Alcoa Research and Alcoa Metallurgy supplied samples. Changed alloys, varied tempers, rolled different thicknesses. The lamp manufacturers tried each in production until one met all requirements. Worked smoothly in high production dies; took a crisp, clean thread; didn't melt or crack at the glassing stage.

Alcoa Process Development Specialists worked long hours to get the right solder and flux to join the side wire connection to the base. Adapted them to the automatic lamp-making machines. Located a manufacturer who would supply production quantities of the special solder wire.

All this time, the lamp manufacturers had aluminum bases installed in seacoast and industrial atmospheres. At our Research Labs we had been testing both lit and unlit lamps under various corrosive conditions. After 3,000 hours of exposure, covering 1½ years, came the report: Aluminum bases measure up to brass in every respect. In corrosion resistance. In conductivity. In ease of installation and removal.

And the cost saving made the changeover decidedly worth while.

Although your problems may have nothing in common with lamp making, Alcoa facilities, experience and specialists in your field are ready to help duplicate the results on a similar long-range program for you, starting now.

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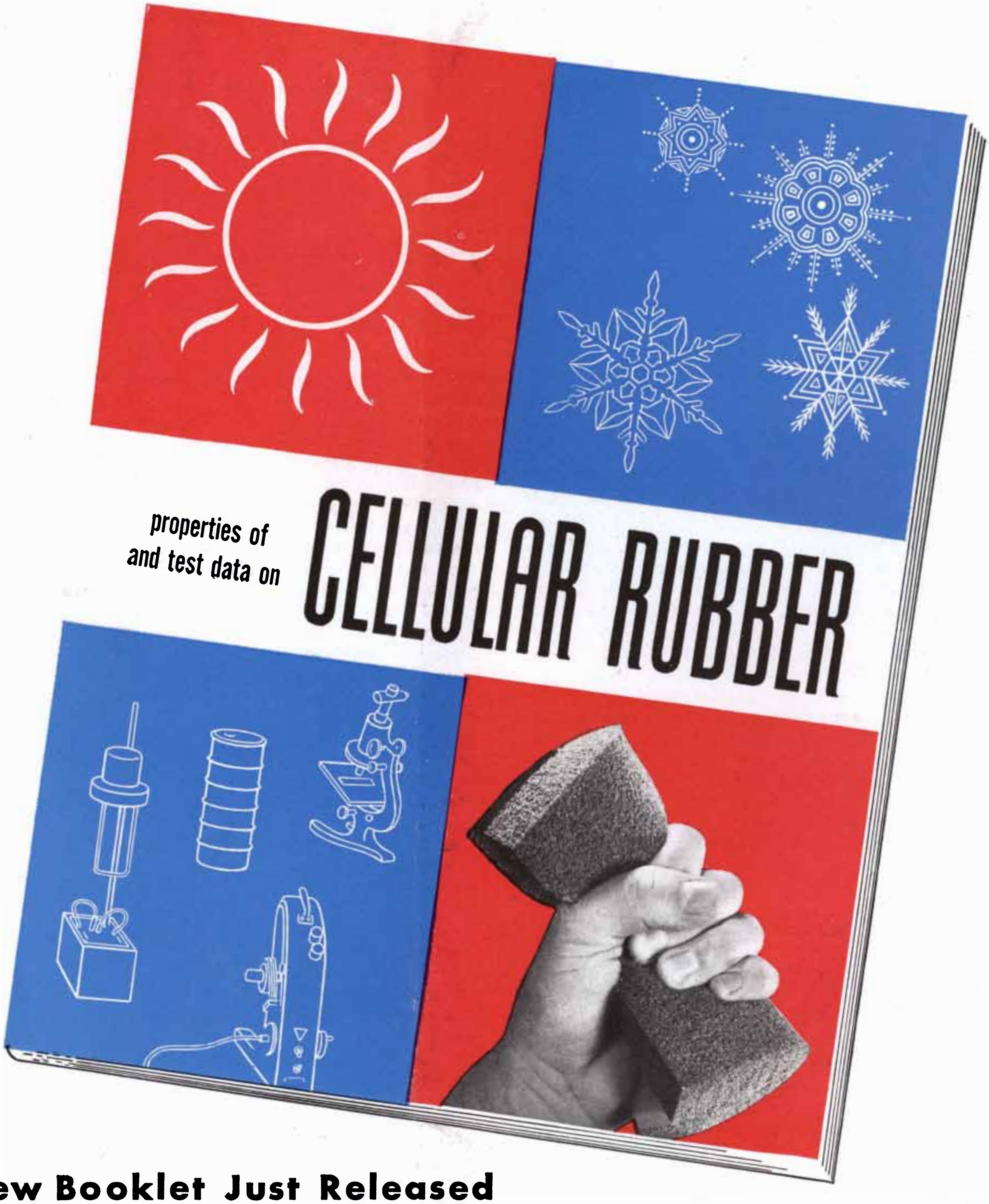
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ENGINEERS

There are 400,000 of them, but they are in acutely short supply. An analysis of this critical situation, with some suggestions as to how it might be alleviated in the future

by Karl T. Compton

THE prosperity of the U. S. in time of peace and its strength in time of war have largely depended, and probably will continue to depend, on our technological progress and industrial production. This fact is abundantly illustrated and documented by the various authorities who have here discussed the subject from many points of view. The Industrial Revolution has proceeded at an ever-increasing tempo in the U. S. One measure of this change is the extent to which machines have replaced hand labor and animal power in our economy. In 1850 only a little more than 5 per cent of America's industrial power was supplied by machines; 79 per cent was furnished by animals and about 15 per cent by human muscles. Today about 84 per cent of our power is supplied by machines and only 12 per cent by animals and 4 per cent by men.

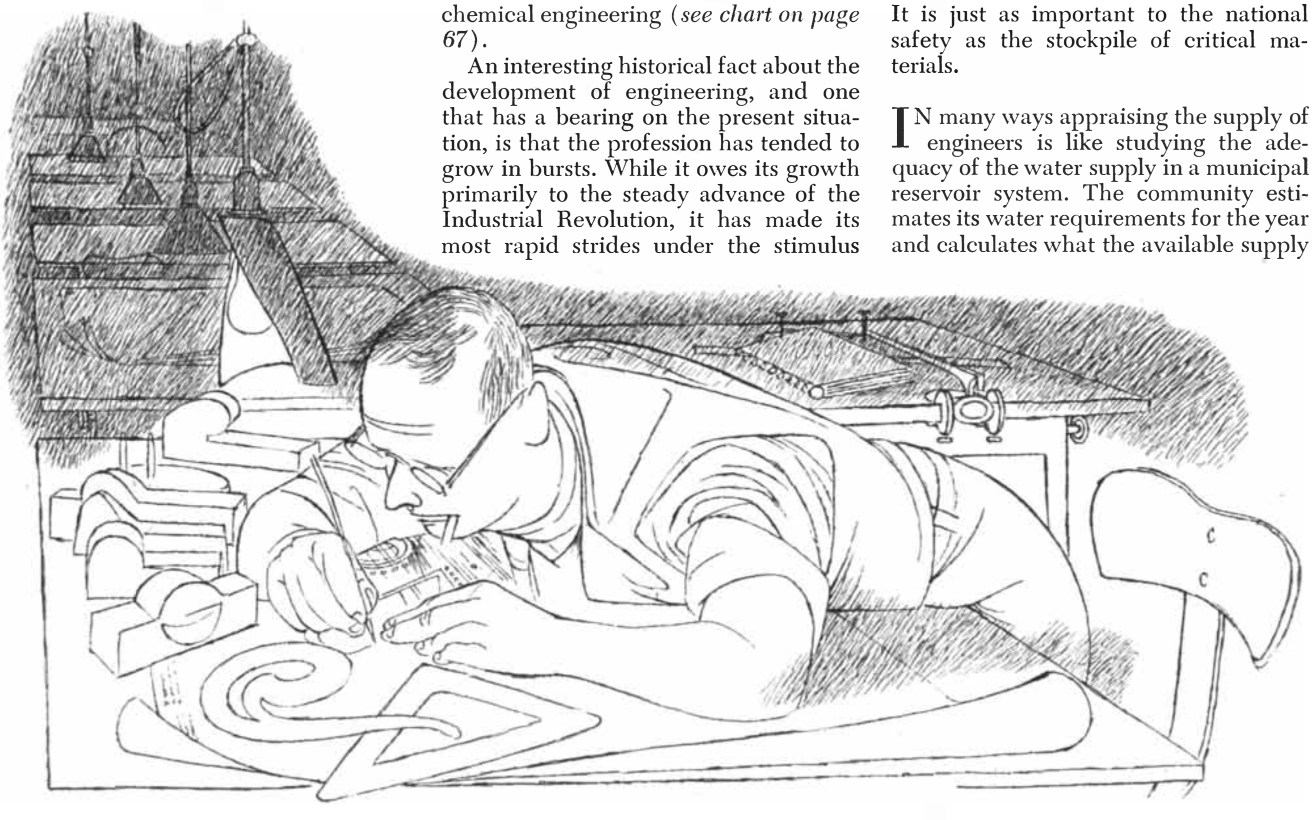
As a consequence the engineer has become an increasingly important factor in our civilization, for it is engineers, for the most part, who design the machines and the products made by machines. The number of engineers in the U. S. has grown from 25,000 in 1890 to 400,000 in 1950, and engineering is now our third largest profession, exceeded only by teaching and nursing. The ratio of engineers to the total number of persons employed in the major industries has increased about fourfold—from one engineer for every 290 workers at the turn of the century to one engineer for every 78 workers in 1940.

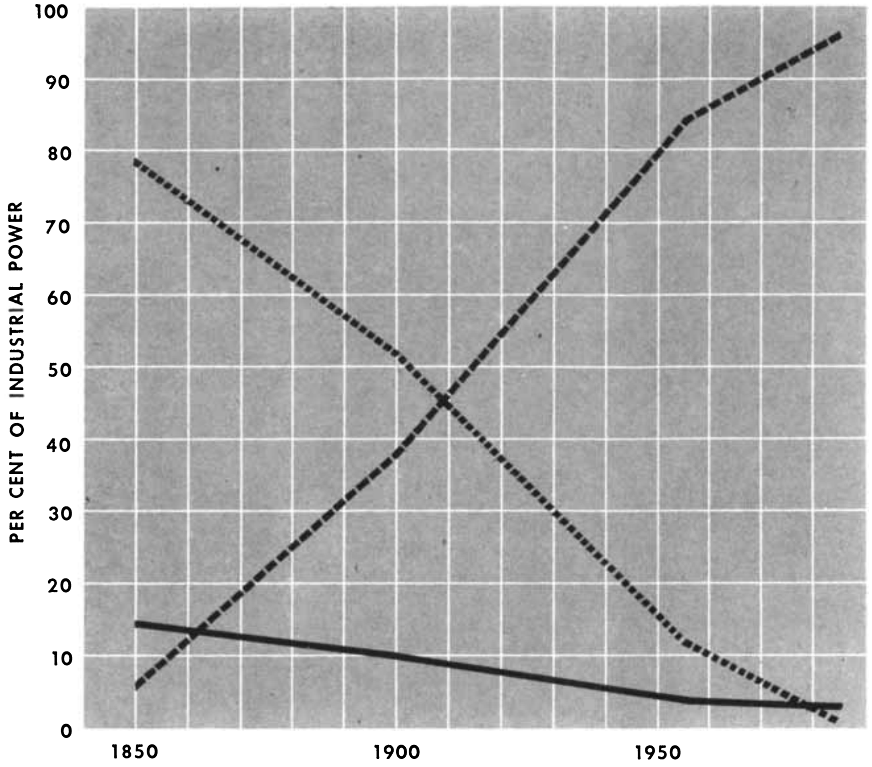
Of the nation's 400,000 engineers about 300,000 are employed by private industry, 90,000 by governmental agencies and 10,000 on the staffs of educational institutions. The engineering profession is a profession of specialists, and it now has more than a score of specific branches; the four major ones are mechanical, electrical, civil and chemical engineering (*see chart on page 67*).

An interesting historical fact about the development of engineering, and one that has a bearing on the present situation, is that the profession has tended to grow in bursts. While it owes its growth primarily to the steady advance of the Industrial Revolution, it has made its most rapid strides under the stimulus of national needs and emergencies. France's greatest technological school, the Ecole Polytechnique, was founded in Paris in 1795 as part of an ambitious movement to rebuild the country from the wreckage left by the French Revolution. In the U. S. the Federal Land Grant Act of 1862, prompted by the need and opportunity for developing the resources of our still pioneer country, initiated the building of most of our engineering schools. In this century the demand for engineers was enormously stimulated by the two world wars, particularly World War II, since modern warfare is waged largely with machines. And now in 1951, in an emergency that calls for increased economic strength and production, the demand for engineers has again become urgent.

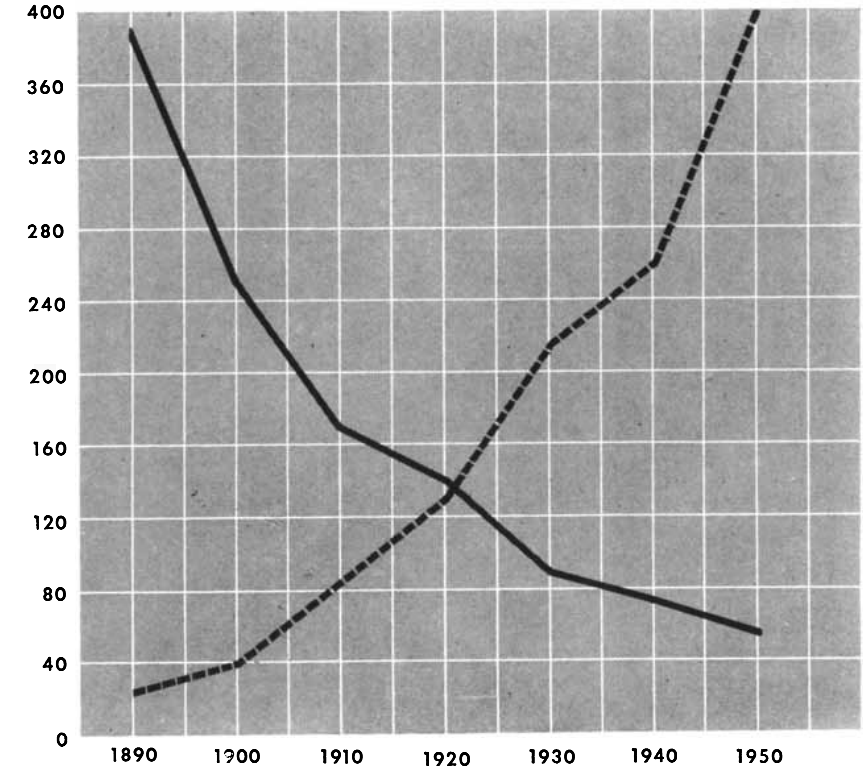
Do we have, or can we get, the engineers we need? The problem is a matter of great concern to industry, the educational institutions and the Government. It is just as important to the national safety as the stockpile of critical materials.

IN many ways appraising the supply of engineers is like studying the adequacy of the water supply in a municipal reservoir system. The community estimates its water requirements for the year and calculates what the available supply





SOURCES OF POWER in industry have changed radically during the past 100 years. In that time men and animals have contributed a smaller and smaller percentage of the power; machines have contributed a larger and larger one. Estimates carry the curves beyond 1980.



NUMBER OF ENGINEERS has increased from 25,000 in 1890. Their proportionate increase is shown by the number of workers for each engineer in five major industrial fields.

is likely to be. To do this it makes an estimate of the amount of rain that is likely to fall over the collecting area and subtracts from that the expected losses by evaporation, soaking into the ground and so on. Similarly it is possible to estimate the future supply of engineers by adding to the number now in the profession those who will be graduated from the engineering colleges, and subtracting from the total the losses through death, age or transfer into other types of employment.

Even in normal times the supply of engineers in relation to demand is a matter of concern to employers, training institutions and students. Surveys of the situation are continually being made by the professional engineering societies, the engineering schools through the American Society for Engineering Education, the personnel officers of firms that employ engineers, the U. S. Office of Education and the U. S. Bureau of Labor Statistics. In 1946 a committee representing these agencies, on which I had the privilege of serving as chairman, made such an estimate. The war, by interrupting normal education, had created a big deficit of engineers. After estimating the demand for the next few years by surveying the plans of industry, government and educational institutions, and calculating the expected supply on the basis of enrollments in the engineering colleges, we concluded that the supply of engineers would catch up with the demand in 1952. Our calculation was that the demand (or deficit) would be reduced from 58,270 in 1948 to 30,260 by 1952 and that the net additions to the supply of engineers in the latter year would be 30,400, just about balancing the demand. This calculation was based on the expectation that graduations from engineering colleges would add an average of about 25,000 engineers a year between 1948 and 1952.

Three unforeseen events upset these predictions. One was the unexpectedly large rush of veterans, under the G.I. Bill's provisions, into engineering colleges. The number of graduates rose to a peak of 50,000 in 1949 and 1950. Another was the unexpectedly large demand for engineers in industry, which came much faster than the industries themselves had anticipated. Finally, with Korea, there came a sudden sharp rise in demand to even higher levels. And this spurt in demand arrived just when the G. I. "bulge" in enrollments had begun to subside. This factor, plus another that we shall consider in a moment, caused a precipitous drop in the number of engineering students.

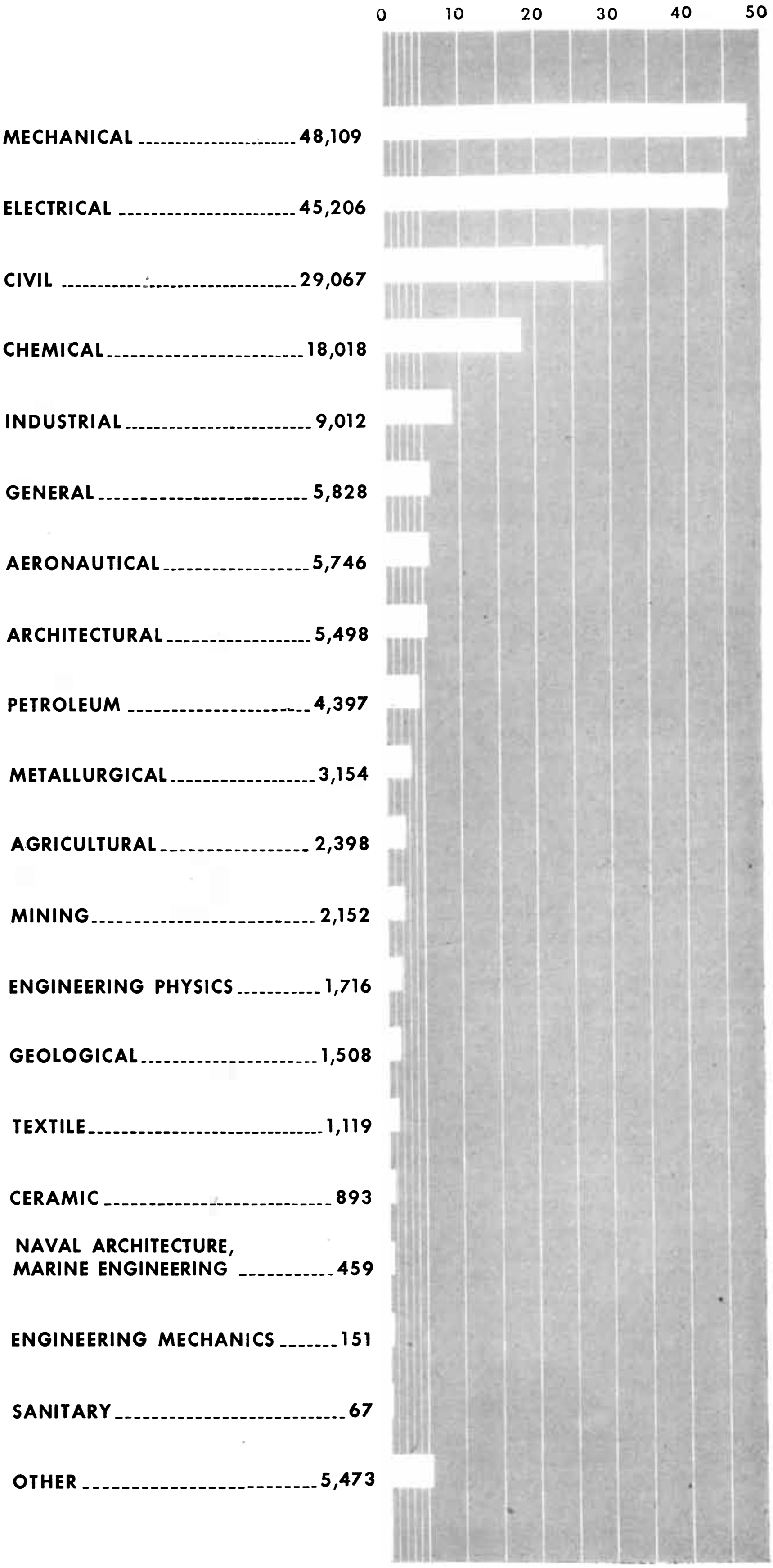
The most optimistic estimates I have seen—those of the U. S. Office of Education—predict that by 1954 the number of engineering graduates will fall to 17,000, even assuming that all engineering students now enrolled in the colleges remain unaffected by the draft and the military situation. A more conservative estimate, made by Dean S. C. Hollister of Cornell University for the Engineering Manpower Commission of the Engineers' Joint Council, puts the 1954 figure at 12,400.

THIS very great decrease in the output of the engineering schools brings the numbers far below the requirements. It falls even below the prewar trend. Why did it occur? The major reason, I believe, was this: Various authorities became convinced that the abnormal increase in the output of graduates in 1949 and 1950 would so glut the market with young engineers that there would be great difficulty in finding jobs for them. These people apparently envisaged for the engineers a fate such as Joseph Addison described for other professions in *The Spectator* in 1711: "I am sometimes very much troubled when I reflect upon the three great professions of divinity, law and physic [medicine]; how they are each of them overburdened with practitioners, and filled with multitudes of ingenious gentlemen that starve one another."

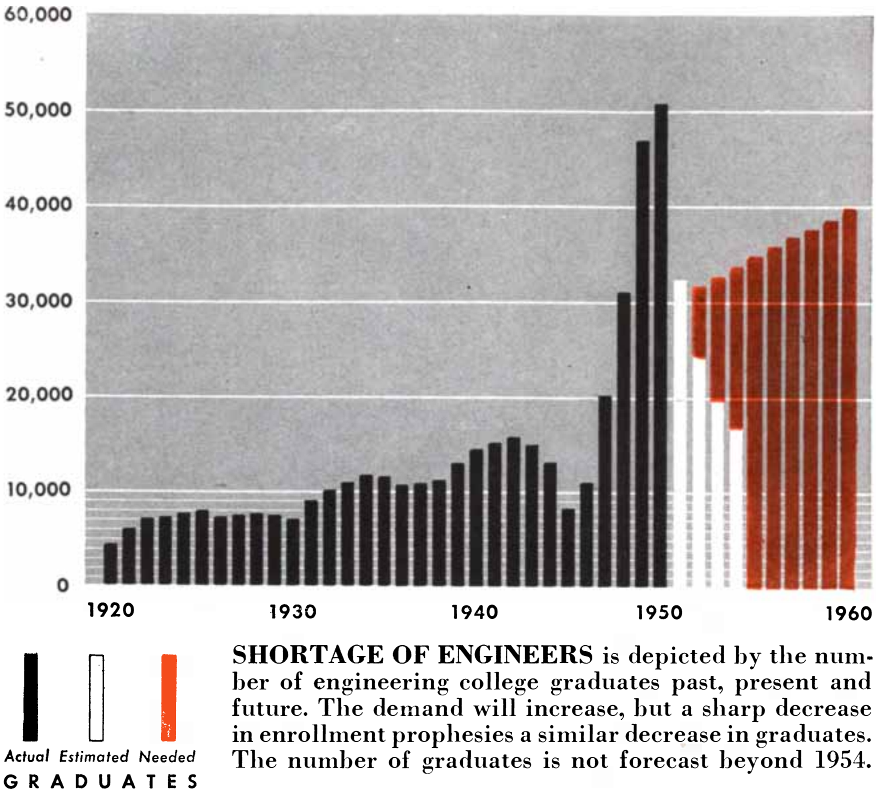
This concern a year or two ago led to many warnings by schools and vocational advisers against the impending surplus of engineers and the danger of unemployment. The engineering schools immediately suffered a drastic drop in new enrollments—a drop nearly three times as large, percentagewise, as in other collegiate groups. College students are sensitive to trends, or even to rumors, as to employment possibilities.

I should not criticize the predictions and advice that led to this result, unless it be on the ground that not enough account was taken of the fact that all past estimates of future demand for engineers had later proved too conservative. Certainly the Korean War could not have been anticipated.

At all events, the fact is that the decrease in engineering college enrollment is having tragic results. The number of graduates in the next few years will be far short of the need for new engineers, which no one estimates to be less than 30,000 per year (*see chart on next page*). The "great science of arithmetic" proves that we are in a very serious situation indeed. We do not have enough engineers to carry through the national program that we have undertaken. Nothing we can do—no Act of Congress, no move by the engineering profession, the engineering colleges or industry—can remedy this situation quickly, and by quickly I mean within three or four years. On the other hand, draft or manpower policies that do not deal understandingly and sympathetically with this situation can quickly change it from bad to worse. Even the most favorable proposals for universal military-service legislation so far dis-



KINDS OF ENGINEERING and the relative number of engineers of each kind are shown in this chart. It does not represent all engineers, but only undergraduate enrollment in engineering colleges for 1949 and 1950.



SHORTAGE OF ENGINEERS is depicted by the number of engineering college graduates past, present and future. The demand will increase, but a sharp decrease in enrollment prophesies a similar decrease in graduates. The number of graduates is not forecast beyond 1954.

cussed will result in shortages more serious than those indicated in the above analysis.

ALL employers of engineers in industry and in government, including the military departments, are keenly aware of the problem, as are the placement officers in the colleges. I recently received a note from our Massachusetts Institute of Technology placement officer saying: "When larger companies and government laboratories write to me to ask for physicists, they send a job description, then add 'as many men as we can get who meet any part of the requirements listed.' The demand for mechanical engineers, electronics engineers and metallurgists is little short of hysterical."

The same statement might equally well be made about other branches of science and engineering. For example, one industrial company last spring reported an unfilled need for 2,000 engineers and scientists.

So we seem to have come to an impasse. Just as we do not have enough steel, or cobalt, or rubber, or manganese to build everything we would like to build, so we do not have enough engineers to handle the jobs that are on our program. What is the intelligent thing to do under the circumstances?

The governmental agencies most directly concerned, such as the National Resources Board, Selective Service, Department of Defense and Office of Defense Mobilization, are all trying to find the best answer. They have called into consultation outstanding representatives from industry and from the leading scientific and engineering societies.

The problem and the facts reported here were presented recently at a conference of some 200 leading engineers and administrators representing the various groups concerned. The spirited discussion that followed yielded a number of suggestions for short-term and long-term remedies. Many agreed that one way to help meet the short-term needs for engineers would be to upgrade promising technical personnel by in-service training programs; this is already being done in some industries and many military establishments, notably in Navy shipyards. It was suggested that there are able engineers in Europe who might be brought here or employed there on a subcontract or cooperative basis.

The conferees agreed that active efforts should be made to correct the recent false impression that there is an oversupply of engineers, and that more top-grade young men should be induced to train for the engineering profession. But fully as important as the recruiting of additional candidates is the problem of keeping those who are already in the engineering schools. As one educator put it: "We must not exchange men on second and third base for a couple of rookies on the bench. We must try to bring them in to score the needed runs."

If human beings could be treated like steel or aluminum or rubber, the obvious emergency answer to the shortage of engineers would be to allocate the available ones to the jobs of highest priority. But to do this by fiat would require a National Service Act far more stringent than is now politically possible. Total exemption of engineers from military duty has been advocated, but in spite of a certain degree of logic it is subject to the charge of being "undemocratic"—a charge that can have a basis of merit as well as a demagogic political slant. Furthermore, there is a very real need for engineers in the military services.

IN this complicated issue, involving national security, economic prosperity and social and political pressures, the following steps seem to be indicated, and some of them are already in operation:

1. Through the control of materials the National Production Authority is indirectly effecting the allocation of engineers to high-priority work, since the withholding of materials from nonessential projects releases manpower for more necessary ones.

2. The Universal Military Service Training legislation permits deferment of men in essential professions and of some college students.

3. Some sort of Scientific and Technical Manpower Board should be set up to establish policies for allocating the disposable manpower in engineering among civilian and military claimants.

4. There are strong arguments for the establishment of a Scientific Corps, or Technical Corps, to which young scientists and engineers of draft status could be assigned for national service whereever needed, and with such insignia and recognition as would eliminate any feeling or charge of being military slackers. The members of such a corps could be in somewhat the same status as those in our present military establishment who are assigned to "engineering duty only."

5. The armed services have been stepping up their reserve officer training programs in the colleges. If the military situation becomes more serious, there will undoubtedly be a program, as in both world wars, to assign draftees to colleges for special training in technical fields in which there are manpower shortages in the military departments. There is equal reason for the Government to sponsor training programs in those civilian fields where manpower shortages are proving to be serious bottlenecks in the national defense effort.

6. For the long term the most important need is to correct the recent widespread impression that the country is oversupplied with engineers. Even before Korea this fear had come to be recognized as a fallacy. There is every good reason for encouraging young men to follow a program of engineering education if they have the urge and talent to do so.

Karl T. Compton, physicist and administrator, is Chairman of the Corporation of the Massachusetts Institute of Technology.

SCIENTISTS

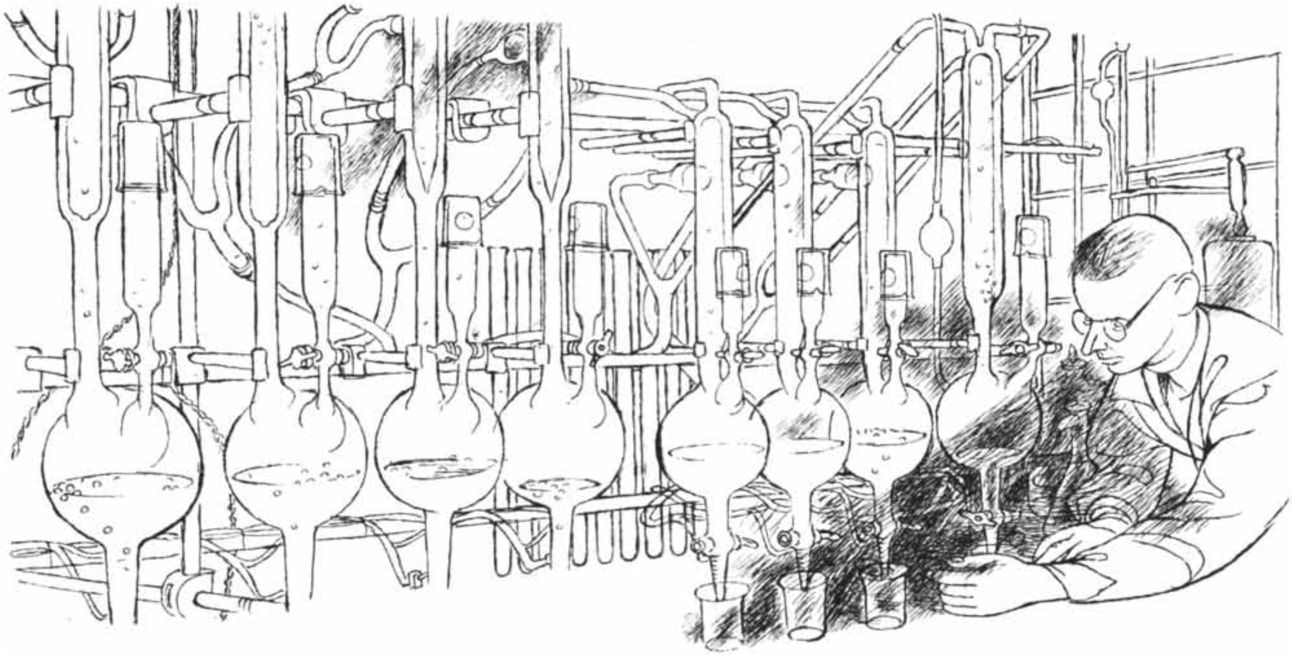
We have 175,000 and need more. The problem is complicated by the fact that applied science takes workers away from pure science, the wellspring of our technological progress

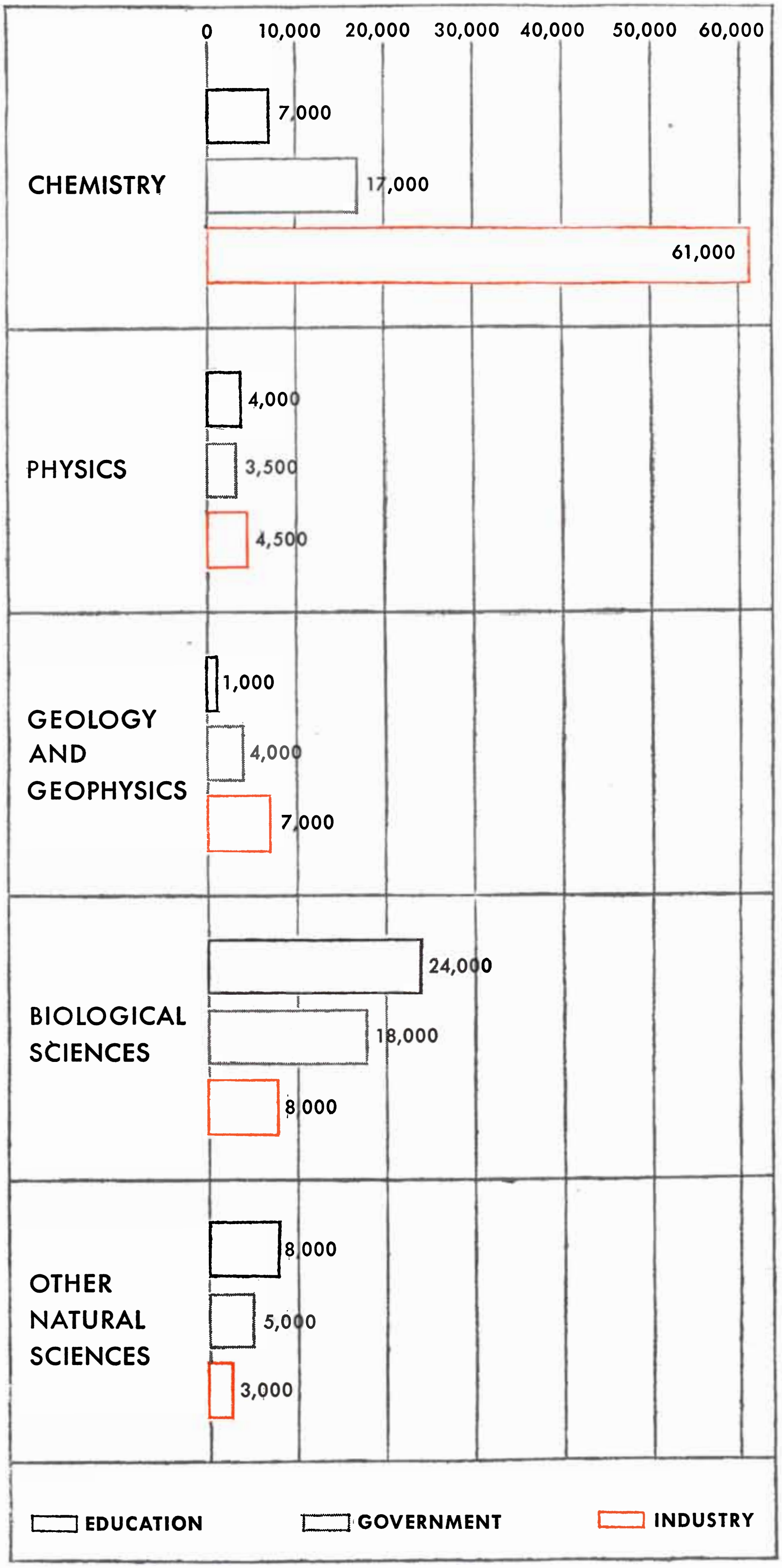
by M. H. Trytten

THE SCIENTIST has two functions in our civilization. One is the timeless quest for more understanding of the nature of our world and the universe—the urge to expand the frontiers of knowledge regardless of whether the new information to be won is immediately useful or not. This has always been the primary meaning of the scientist's calling, and for thousands of years it was almost the only one; scientists took pride in keeping their curiosity and pursuit of knowledge as "pure" as possible. But in an industrial civilization the scientist is called upon more and more to perform another important function: namely, to apply his knowledge and methods of investigation to the complex technical problems of the civilization. In a technological society as highly developed as ours, the practical application and exploitation of basic discoveries is not solely a matter of engineering. Our industry needs and employs physicists, chemists, biologists, geologists, psychologists, even that most esoteric of all groups—the pure mathematicians.

Science has therefore become a large profession, and the demand for its services is growing at a rapid rate. The most insistent and effective demand comes from business. Of the 175,000 scientists in the U. S., nearly half are employed by private industry, a little more than a fourth by government agencies and only a fourth by the universities, where most of the work in pure science is done. Since the turn of the century, and particularly within the past decade, the scientist has faced an increasingly perplexing choice: whether to go into basic science, which he usually would prefer, or into applied science, where the economic rewards are more attractive. In the present emergency, when there are not enough scientists for our research needs in either basic or applied science, this dichotomy aggravates our quandary. The shortage of scientists presents a double problem: On the one hand there is a pressing need for their services in applied fields to increase our national power and productivity. On the other, there is the equally great need for basic research and discovery, which we must have if we are to continue our technical progress and leadership. It is a disquieting fact that even before the present emergency basic research was getting less and less relative attention, and the new emergency demands threaten to make the situation much worse.

THAT the U. S. is already experiencing a shortage of scientists needs no elaborate proof. What Karl Compton has reported in the preceding article about the demand for engineers also holds true generally for scientists. At a recent meeting of the research committee of the National Association of Manufacturers attended by representatives of more than 100 leading companies, every company related that it was having difficulty in filling its needs for scientists. Last spring





NUMBER OF SCIENTISTS in the various broad specialties and in education, Government and industry is shown on this chart. The largest specialized group is composed of chemists, most of whom are engaged in industry.

16 major employers of scientific personnel, each company a leader in its field, reported that after scouting the nation's graduating classes they were able to obtain on the average only 36 per cent of the new employees they needed. Another measure of the shortage and the urgency of the demand is the unprecedentedly high starting salaries being offered these graduates. For graduates with the bachelor's degree starting salaries of more than $5,000 a year are not uncommon, and newly graduated Ph.D.'s are being hired at salaries up to $7,800 a year.

This demand is not due solely to the present emergency. The employment of scientists has been expanding rapidly since 1940, and it rose tremendously in the postwar period even before Korea. For example, the nation's industrial laboratories, which had a total of only 36,000 research workers in 1940, increased this number to 54,300 by 1946 and to 70,500 by 1950. The laboratories of our military establishment employed more than 10 times as many scientists and engineers after the war as they had before. The atomic energy enterprise added a whole new field to the nation's scientific activity, demanding many thousands of scientists and technicians. Since the war, medical and pharmaceutical research in the U. S. has become a multimillion-dollar enterprise, employing still another sizable army of scientists.

To all this the emergency that began with Korea, producing a great acceleration of the national program of research, has added large new demands for scientists. Eric A. Walker, of the Department of Defense Research and Development Board, said recently: "The expanding programs planned by the Department of Defense and the Atomic Energy Commission will probably absorb something like three-fourths of the national supply of technically trained personnel."

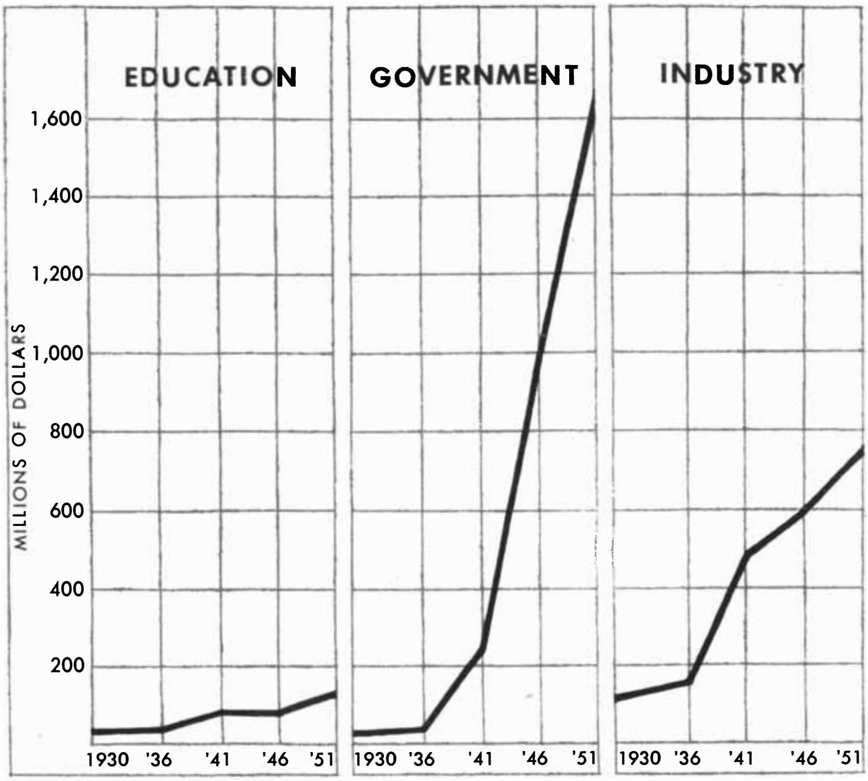
Efforts are now being made to compile estimates of the numbers of scientists that the emergency will require in various fields. Since industry, government and the universities were absorbing virtually all the available science graduates before the emergency, it is obvious that the supply will fall far short of the new demands. This would be true even if our colleges and universities continued to turn out as many scientists as they have in recent years. Actually the supply will be falling while the demand is rising.

In the first place, the number of college graduates will drop sharply in the next few years, even disregarding the effects of the military draft. This is due to the fact that the postwar wave of G.I. students has passed through the colleges and enrollments are returning to normal. In 1950 330,000 men graduated from U. S. colleges; by 1954 the number will fall to 148,000 or less. This gives a rough indication of the probable percentage drop in the output of scientists, for year by year about the same proportion of college students major in science. In 1950 there were 75,000 science graduates, including 6,970 women; in 1951, only 47,000. On the basis of present enrollments the number of science graduates will decline further to 36,000 in 1952, to 33,500 in 1953 and to 29,000 in 1954. And this forecast does not take account of military mobilization. Probably about half of the science and engineering students in the colleges are draft-vulnerable or in the military reserves.

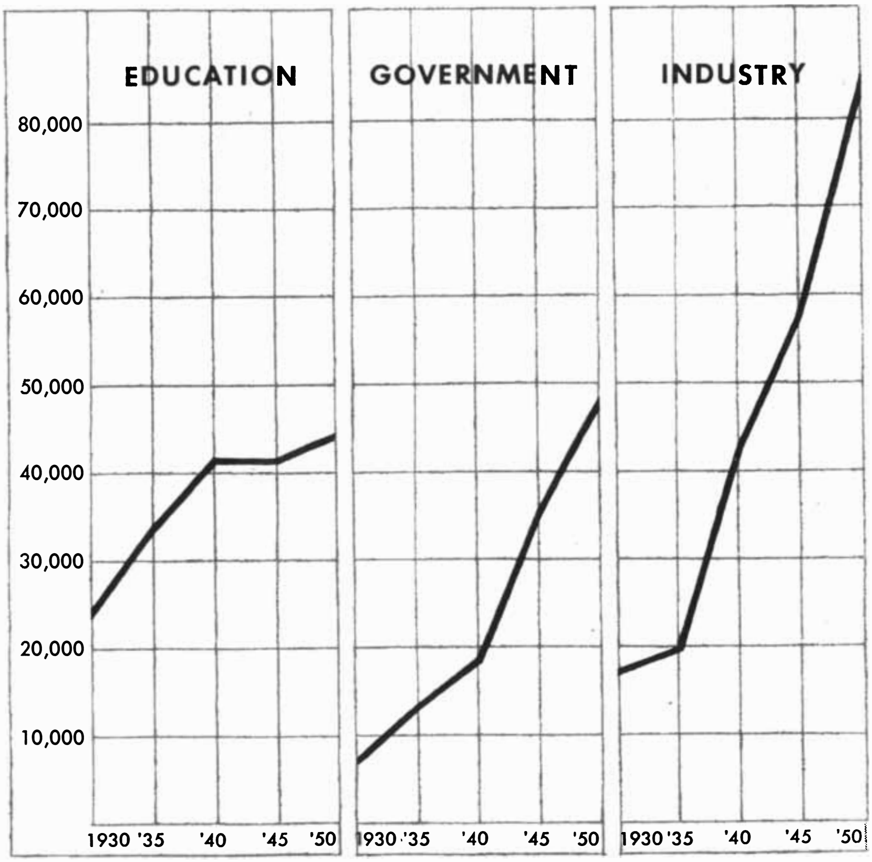
FROM the standpoint of our supply of research scientists the crux of the problem is not the output of college graduates but the production of Ph.D.'s. The leaders and creative workers in science, particularly in basic research, come mainly from the ranks of those who have had the research training that goes with the doctorate degree. As of July 1, 1950, the U. S. had an estimated 40,000 Ph.D.'s in science. They included 16,375 chemists and biochemists, 8,260 biologists, 3,561 physicists, 3,220 medical scientists, 2,690 psychologists, 1,950 mathematicians, 1,860 earth scientists, 1,790 agricultural scientists and 210 astronomers. Before the war the nation's universities produced about 1,500 Ph.D.'s a year in the natural sciences; the number dipped sharply during the war, but it rose afterward, reaching 3,350 in 1950 and 3,550 this year. Now it has begun to decline, and in a year or two the number will be sharply reduced, mainly because of the general fall in college enrollments.

The problem of training Ph.D.'s is not primarily financial. Graduate students working for the Ph.D. as a rule do not have to depend on family funds for support. Before the war most of them supported themselves by working as teaching assistants, and since then other subsidies have been added—notably veterans' benefits (which during the past three years have supported nearly half of the nation's graduate students in the sciences), Government research contracts and new fellowships offered by the Atomic Energy Commission, private foundations and, soon, the National Science Foundation.

As Dael Wolfle points out in his article on intellectual resources in this issue, we can increase the supply of Ph.D.'s substantially only by increasing the number of able young people we send to college. In other words, we need a larger pool of potential candidates on which to draw. Even if every capable and interested young person who now graduates from college were offered financial support to do graduate work, it is doubtful that we could greatly increase the output of Ph.D.'s. In 1948 the Office of Scientific Personnel looked into this question by asking the heads of science



AMOUNT OF MONEY spent for scientific research in education, government and industry is shown by three curves. Industrial expenditures rose steeply, those in government even more so and those in education very little.



INCREASE OF SCIENTISTS in the three fields is shown by these curves. There was no increase of scientists in education during the war, and their rate of increase even now lags behind that in the other fields.

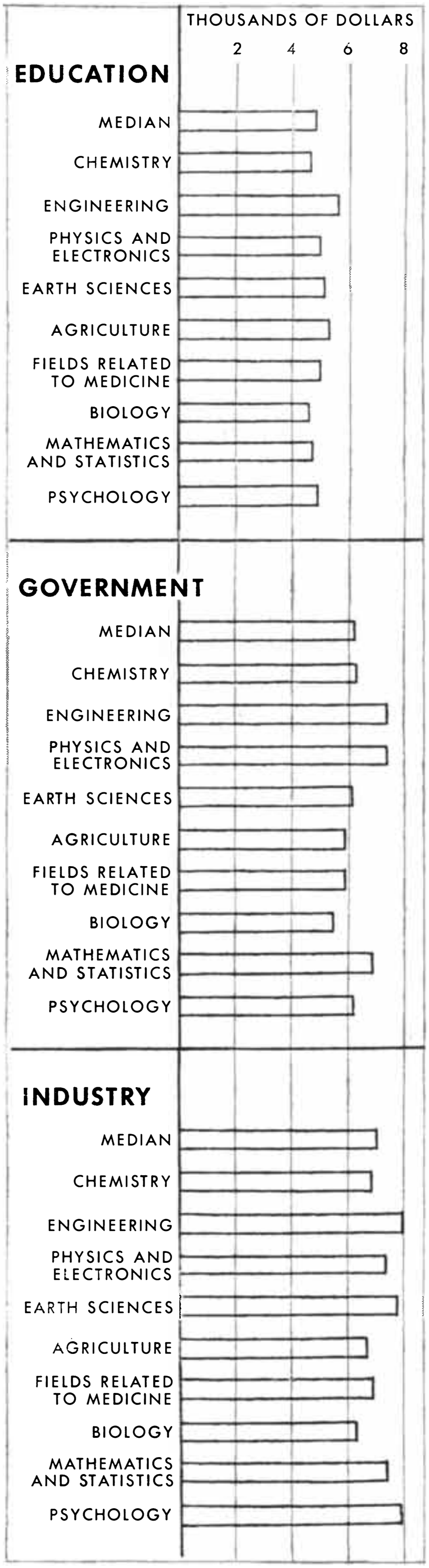
departments in the colleges how many of their graduating science majors they considered competent to go on to obtain a Ph.D. and what proportion were interested in doing so. Their replies, covering about four-fifths of the 1948 science graduates from the nation's undergraduate colleges, put the total number of qualified and interested Ph.D. candidates at 3,800. The true number was probably smaller, for experience has shown that estimates of students' capabilities are always on the optimistic side; a fair estimate would be 3,200 to 3,500. This is no larger than the number that actually received the Ph.D. in 1950. Taking into account the fact that college enrollments have fallen since 1948 and will decline much more sharply in the next few years, it is obvious that we shall not have enough qualified and interested candidates to keep the Ph.D. output even at the present level.

NOW LET US look a little more closely into the effect that the shortage of scientists, the trend toward applied science and the current mobilization are having on basic science in the U. S.

At the end of World War II everyone agreed that the U. S., whose contributions in the past had been mainly in the field of technology, should turn to much more emphasis on basic research. In Europe, which had been the major source of the world's great scientific progress during the past two centuries, the scientific enterprise had been all but destroyed and work had almost stopped. Without further progress in scientific discovery, technology would soon reach a dead end. It was obvious to the nation's leaders, including those in Government, that the U. S. must take the leadership and shoulder the responsibility for the march of fundamental discovery. Programs for the expansion of basic scientific work in the U. S. were laid down in several official reports.

In spite of all this the trend since the war has gone in the opposite direction; the emphasis has actually shifted more and more to applied science rather than basic science. An increasing share of the nation's research funds has been spent in engineering and development work. And with the funds have gone the scientists. An ever larger proportion of them have been drawn into programs that are mainly applied research, if indeed they can be called research at all. In fact, many of our most productive scientists have abandoned research altogether and become administrators or policy makers.

This trend is graphically told in the figures. Before the war the leading occupation of the nation's scientists was university research and education: of the total of some 92,000 scientists, 40,000 were employed in colleges and universities, 35,000 in industry and 17,000 in the Government. During the war there was, of course, a considerable shift to Government and industrial laboratories, but by 1947 the universities had recovered a major share of the available scientists: they had 50,000, compared with 57,000 in industry and 30,000 in Government.



MEDIAN SALARY of Ph.D.'s in education is $4,860; in Government, $6,280; in industry, $7,070. Salaries of those within groups are similar.

In that year the Steelman Report forecast, on the basis of plans for expanding basic research and of what then appeared to be the trend, that by 1950 there would be 75,000 scientists in colleges and universities, 68,000 in industry and 33,000 in Government. The forecast was correct as to the total number of scientists, but it was far off on their distribution. As we have seen, in 1950 the universities, instead of leading in the employment of scientists, were at the tail end: they had about 44,000 scientists to industry's 83,500 and Government's 47,500.

The reasons for this are no mystery. Industry and the Government have offered scientists bigger research budgets, bigger and better laboratories, more assistants and higher salaries. The salary edge is considerable; as our recent study showed, in 1949 the average salary paid to scientists with Ph.D.'s was $7,070 in industry, $6,280 in Government and only $4,860 in educational institutions.

This disparity is now being widened by the present emergency demand for scientists by industrial and governmental laboratories. The salaries they are offering are so much higher than universities can pay that comparatively few graduates in science are entering academic careers. Moreover, military research projects, military service and other emergency duties are taking many scientists away from the campuses. In short, the force of current events is accelerating the trend away from basic science.

WE HAVE many important manpower problems, but it is doubtful that any is more important to our future than this one. We must somehow find a way to use our scientific manpower to go ahead as rapidly as possible in basic science as well as to meet our immediate needs in technology. Fundamentally there is only one long-run answer to the problem of the supply of scientists: we need to do a better job, from high school on, of teaching, inspiring, encouraging and financing our able youngsters to take up careers in science—and this includes making such careers more attractive by improving scientists' pay. We face immediately, however, the problem of striking a proper balance between our efforts in basic science and in applied science, and beyond that between our military preparations and the over-all development of our strength as a nation. So far our national effort has been one-sided. We are providing the money and the metal for national defense, but we have done very little to provide the trained manpower upon which our strength finally depends.

M. H. Trytten, physicist, is Director of the Office of Scientific Personnel of the National Research Council.

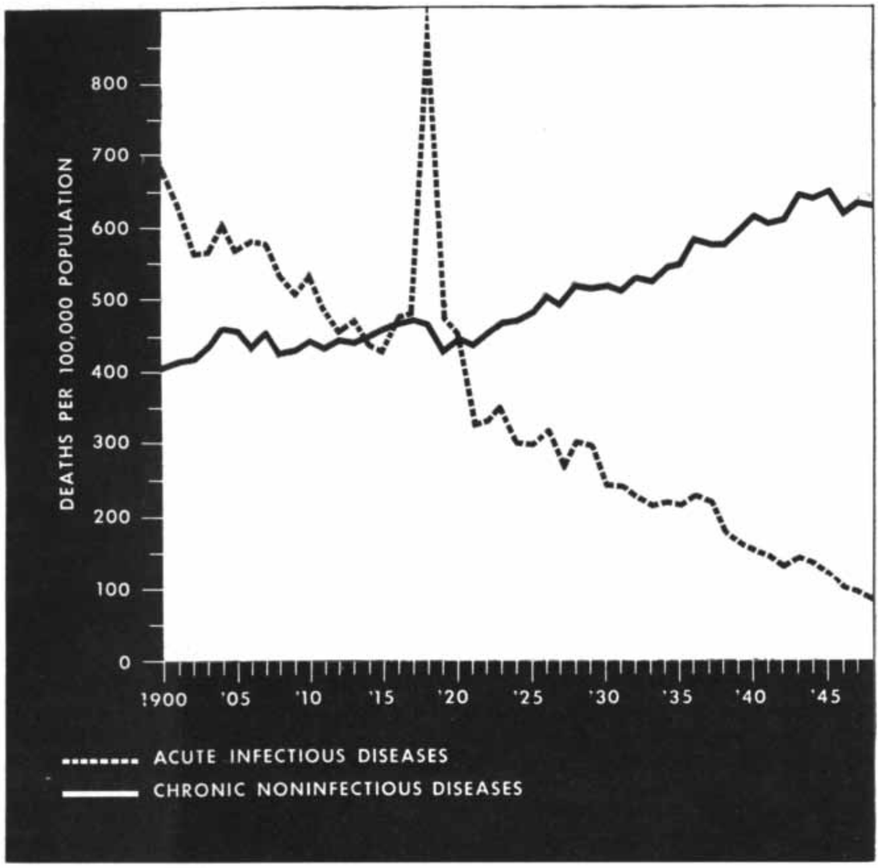
DOCTORS

There are 209,000 M.D.'s. When we attempt to estimate whether we will have enough we must consider not only the demand for medical care but also the need for it

by Alan Gregg

ANYONE who undertakes to assess our medical manpower situation must first consider the question "medical manpower to do what?" The work of doctors is not, and never will be, a fixed and unchanging task, particularly in a dynamic country like the U. S., where not only the national scene but medicine itself is constantly in motion. To understand what is implied by such an idea as the shortage of doctors we need to examine the nature and amount of the services they will be expected to perform. Let us, then, look at some of the broader aspects of medical care—at the trends rather than only the latest figures, the dynamics rather than the statistics of the situation.

Medicine has much more to offer today than it used to have. The Harvard biological chemist Lawrence J. Henderson once remarked that somewhere around 1910 the progress of medicine in America reached a point where it became possible to say that a random patient with a random disease consulting a physician at random stood better than a 50-50 chance of benefiting from the encounter. In the 40 years since then the chances have improved a good bit beyond that. The 14 million Americans who served in the military forces in World War II were given a notable demonstration of how far medicine had progressed: among our military personnel during that war there were only six



DEATHS in the U. S. from infectious diseases have dropped from 681.5 per 100,000 population in 1900 to 88 in 1948. In the same time deaths from noninfectious diseases have risen from 407.9 to 627.1. The tall peak on the curve of infectious diseases is the influenza epidemic of 1918.

deaths from disease per year for every 160 such deaths in World War I, 250 in the Spanish-American War and 650 on the Northern side in the Civil War. To turn to an example from civilian life: Chicago 20 years ago had 6,012 reported cases of diphtheria with 513 deaths; last year, five cases with no deaths.

Most people, however, seem to ignore an obvious but nonetheless remarkable consequence of the steady improvement in the quality of medical service; namely, the more doctors can do for people, the larger becomes the demand for medical services. I can remember the heated debates I heard in my childhood as to whether the automobile would ever take the place of the horse. Very few foresaw then that advances in automotive technology and manufacture would make the automobile less expensive, more dependable, more durable, more powerful, more useful, less noisy and less smelly. Almost no one seemed to realize that with better cars roads would be multiplied and improved. Improvement increases demand, and increased demand in turn creates and rewards still further improvement. This is as true in medicine as in technology. The love of good medical care seems to follow Shakespeare's observation that "love grows by what it feeds on."

As a result, the entire horizon of medical care has changed. An increasing number of people want the better care that is now available. Whereas medical care used to be considered a privilege of the rich or a boon given in the name of charity to the poor, it is now coming to be thought of as a necessity that more and more people insist on having, if necessary by taxation. And at that point a revolutionary change occurs in the horizon of medicine: instead of calculating increases in the *demand* for medical care, we face the task of estimating the *need* for medical care.

NO DOCTOR needs to be told that the number of persons who need medical care is at present immeasurably greater than those who are asking for it or getting it. We have no detailed census of the defects and diseases (what the doctor calls "morbidity") among the American people, or even of how much of that need ever turns into explicit demand for the services of doctor, dentist or nurse. But such samplings as have been taken suggest that the unrecorded need far exceeds the recorded demand. So if the trend of the times is clearly toward meeting the need, we can sensibly dispense with the spurious accuracy of close figuring based on the records of demand. Witness the pressure on the Veterans Administration to include medical care of nonservice-connected disabilities and dependents. If you supply "free" (*i.e.*, tax-supported) medical care to 14 million young persons in the services who are now civilians and voting, and maintain a growing Veterans Administration medical service the while, and now plan for a military establishment involving 3.5 million more young people in the immediate future, you have started changes in the citizens' attitude toward medical care that are worth thinking about in terms that transcend mere arithmetic. By all odds the most important change in the horizon of medicine as a whole is its improved and improving potential value and the increasing realization of that value by an increasing number of people in need who are coming to consider medical care as a civic right.

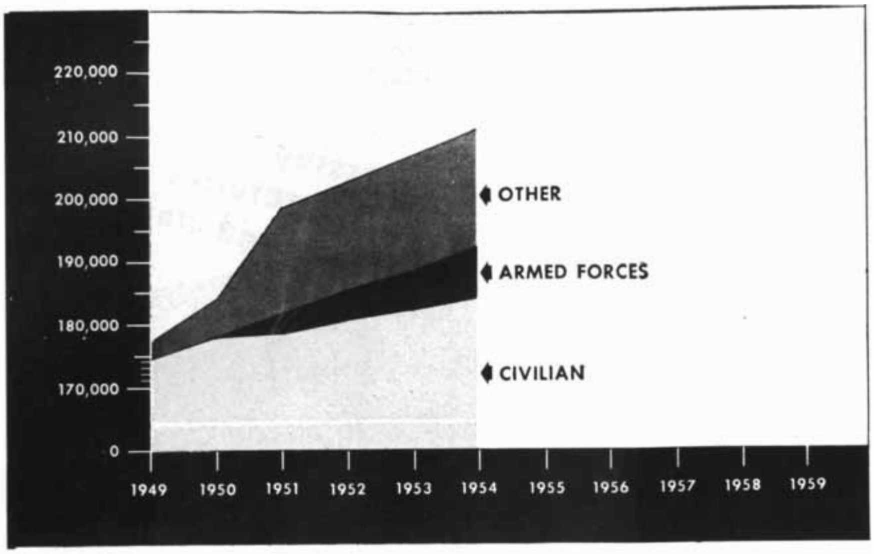
Here, then, is one factor that has vastly increased the need for doctors. There are others. In the decade from 1940 to 1950 we added 19 million to our population. At the current ratio of one doctor to 850 civilians, this population increase alone would call for 23,000 more doctors than we had in 1940, and the need may continue to rise at a comparable rate in the coming decades as our population goes on growing. There is also the fact that the life span of our people is lengthening, which means that we have more elderly people. As we master the acute infectious diseases, we are seeing more people reach the age when chronic and degenerative diseases are likely to call for medical care; to some extent we have traded mortality for morbidity.

To all this we must add the increased need for doctors imposed by the present military mobilization. If the armed forces are to have 35 doctors per 10,000 men under arms, then the planned military establishment of 3.5 million men will call for 12,250 doctors. This is just about three times as many doctors as would be needed to take care of the same number of people as civilians, because the military doctor-to-population ratio is three times that in civilian life. Nor is that all. In the event of war the need for doctors would rise at home as well as in the military establishment, for civilian populations in wartime have their own peculiar demands. Civilian defense measures call for doctors. And one doctor killed or severely injured in an air raid leaves 850 civilians in search of another doctor, whether or not the bombs have fallen on them! Also, when industry is geared to war production, we must have more industrial physicians and more doctors to rehabilitate some of the four million handicapped persons who could be reclaimed for productive work.

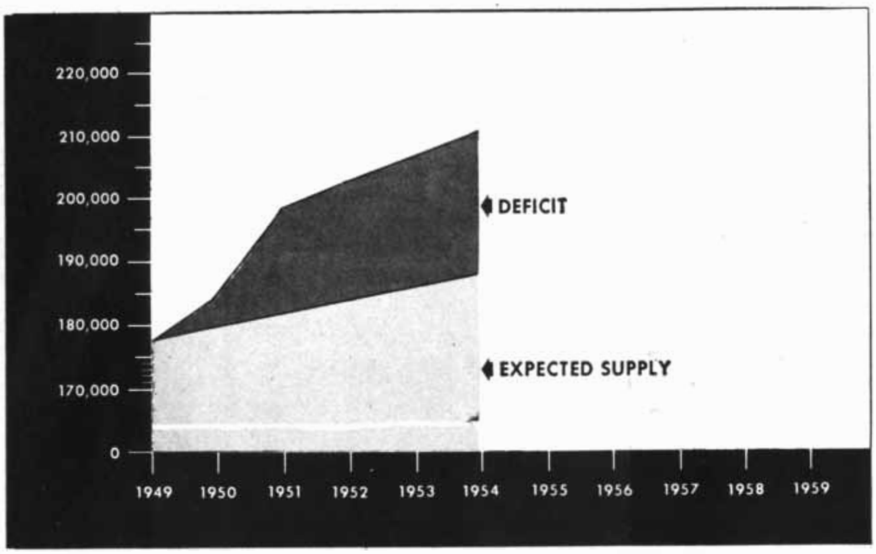
NOT ALL of the trends in medicine or our national life are in the direction of piling up demand for more and more doctors. Medicine and health work are becoming more efficient in the use of manpower. By means of surer and earlier diagnosis, more effective drugs and forms of treatment, more preventive medicine, a higher standard of living, more widespread knowledge of hygiene among the laity, better hospital organization, more auxiliary personnel to save the doctor's time—by means of all of these, today's doctor can take effective care of more patients than ever before. There are far more hospitals than there used to be, and the average stay in the hospital is shorter. Automobiles and better roads have enormously reduced the time a doctor spends in mere travel. Group practice, when the standards of the group are high, is an economy of time, effort and money to all concerned. Yet there are factors that offset these aids. The practice of medicine at its best still requires personal service that is not that of the assembly line. A doctor cannot communicate with his patients over a public address system. And medicine cannot be very efficient where the population is sparse and scattered and without adequate hospitals. In these areas we have a chronic shortage of doctors, which cannot be corrected by the airy generalization that all we need is a redistribution of the doctors. If the demand for doctors' services were not increasing everywhere, the problems of distribution might stand a better chance of solution without any increase in the total number of doctors. But as long as the interesting opportunities in the profession exceed the number of well-trained men, the well-trained men will prefer to go where those opportunities are, that is, the cities and industrial centers.

The story of the unequal distribution of doctors can be told in a few figures. In 1949 nearly two thirds of the nation's 180,000 active physicians in private practice were concentrated in the populous regions of the East, the Midwest and the Pacific Coast. The Middle Atlantic states, for example, had one doctor for every 625 people, while the so-called Deep South had only one for every 1,300—in other words, half as many in proportion to population. But the problem of medical care for the underprivileged areas will not be solved until those regions are provided with more hospital beds, medical facilities and auxiliary help—and until the nation as a whole gets more doctors, more dentists, more nurses, more trained persons in every health service.

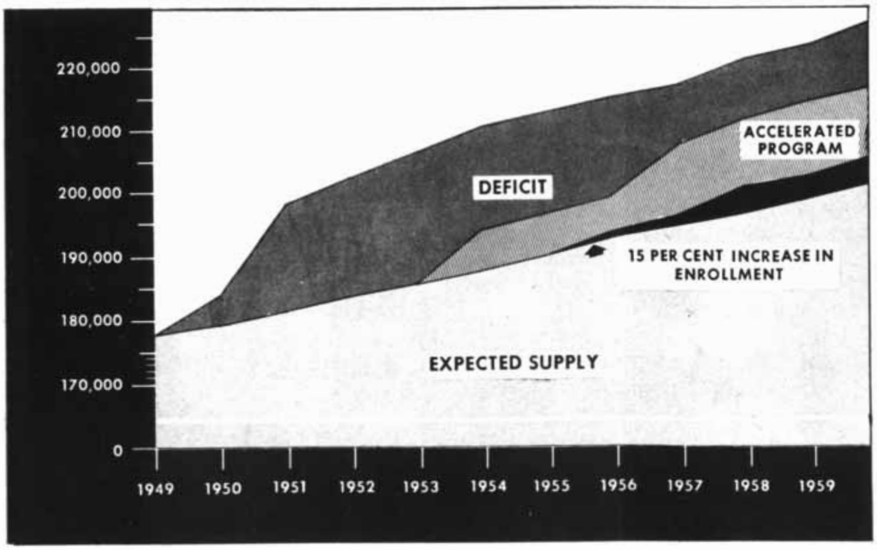
NOW what are the prospects for increasing our supply of doctors? It can be said at once that the profession of medicine in the U. S. does not suffer from the handicap of unattractive pay, as some other intellectual occupations do. A survey just completed by the Department of Commerce and the American Medical Association shows that the average net income of physicians in ci-



NEED FOR ACTIVE DOCTORS in 1954 is estimated at 210,600, with 183,700 civilian and 18,500 military. Some doctors are not in active category.



SHORTAGE OF ACTIVE DOCTORS may be 22,000. These charts are based on estimates by Howard A. Rusk of the National Security Resources Board.



TRAINING OF ACTIVE DOCTORS might be manipulated to decrease the shortage after 1953. Increase in enrollment would not be felt until 1955.

vilian practice in 1949 was $11,058. There is no dearth of potential candidates for medicine in our colleges. The bottleneck lies in the matter of medical education.

In the first place, the length and cost of medical training are a formidable barrier. No one knows how many able and apt young men and women in the U. S. renounce careers in medicine for economic reasons, but the number must certainly be large. Even if they can afford the fees in medical school, many cannot afford to spend the long period of their lives in preparation that medicine requires. To speak of a medical education as a matter of four years recalls the English philosopher Francis Cornford's definition of propaganda as "the art of lying in such a way as nearly to deceive your friends without ever taking in your enemies." The M.D. degree is only the first step; its holder must then spend one, two or more years in internship and further training to become a really competent, fully prepared doctor. The fact is that a good medical education takes not four years but eight or ten, whether it be for practice as a physician, for teaching or for research.

Little can be done to shorten the time of training. Nor can the medical schools, on the present basis of support, reduce the price of an M.D. degree. Even in those that receive the highest tuition fees, the fees pay only from one-quarter to one-seventh of the actual cost of instruction. In 1949 the average tuition fee in our medical schools was $548, but the schools spent, on the average, $2,577 per student. In a sense, therefore, all medical students are on part scholarships.

In spite of the economic barriers, the medical schools have nearly four times as many applicants as they can accept. Yet here again, paradoxically, difficulties arise. As the Greeks observed, there are only two groups in a peaceful society who may kill human beings with impunity—judges and doctors. The selection of candidates for medicine requires care. Since every student receives an education that costs far more than he pays for it, medical-school admissions committees are loath to accept students who are likely to disappoint their teachers or later disappoint or exploit the public. Candidates who rank below average in their class as premedical students are not the sort they want to admit. Yet scholastic grades alone do not tell everything about a student's qualifications to practice medicine. Among all the M.D.'s who have passed muster scholastically there are still too few real doctors. In weighing candidates the admissions committees must take into account health, motivation, tenacity of purpose, character and emotional stability. They are always conscious of the necessity for controlling the wastage involved in the fact that about 10 per cent of the students who start in medical school drop out before they finish, because of ill health, collapse of economic resources, inadequate scholastic performance or loss of interest, especially among those who never really wanted to become doctors but were pushed into it by parental pressure.

THERE ARE 72 four-year medical schools in the U. S. and seven others that provide only the first two years of medical instruction. At the beginning of the school year last fall the 79 schools had a total enrollment of 7,187 first-year students, 6,720 second-year students, 6,256 third-year students and 6,030 fourth-year students. This fall probably 7,500 new students will be admitted to the first year.

The first-year class last year ranged in size from 20-odd in the smallest of the two-year schools to more than 160 in one of the state universities. The teaching of medicine calls for individual instruction in small groups, for student participation in laboratory work and for teaching by example and controlled experience under close supervision. This means that enrollments must be kept small: a class of over 100 students begins to put a heavy load on the heads of teaching departments, and a class of 150 is commonly regarded as excessive, especially when the laboratory facilities were built for only one-half or two-thirds that number. The quality of instruction suffers when the student's identity is lost in a class too large for the professor to know his students.

During the four years of medical school a student studies some 20 required subjects. The teacher's load is increased by the fact that in almost every subject in the medical curriculum new knowledge steadily adds to or refines the information he must offer the students. The younger teachers have another worry: they must carry on original laboratory or clinical work, because they know that promotion is influenced by the quality and quantity of their published research. Besides all this our medical schools are now feeling the pressures resulting from the rising costs of equipment, supplies and building, from the dislocations and interruptions of teacher training due to the war and from the loss of endowment income during the last depression.

HOW COULD the medical schools increase the number of their graduates? If time were not of the essence, the wisest course would be to fill out most of the two-year schools by adding the two final years and to create new four-year schools in states possessing none, such as New Jersey and Florida. But this will be slow and extremely expensive, and the new schools could not be expected to produce any graduates before 1957. Furthermore, with at least 250 teaching vacancies already in existence in the present medical schools, it would be no small feat to staff the new ones.

The medical schools have undertaken to increase their output by admitting more students (about 1,000 more this fall than two years ago) and reducing the losses of students who fail to finish. But the only way to produce a substantial increase in the number of graduates in the immediate future would be to resort to acceleration, as the medical schools did during World War II. They reduced the four-year course to three by operating continuously, without stopping for the summer quarter. Both in promptness of results and in volume of production over a period of years, the numerical gains of acceleration are certain and obvious. But the experience during the war showed that in nearly every other way acceleration is unsatisfactory. True, it increases the total tuition income per year. But it imposes a tremendous load on the teachers and students, which during the war was reflected in the quality of student performance. Acceleration proved so exhausting to both teachers and students that probably nothing short of a declared war would induce the medical schools to repeat the experience; their attitude toward acceleration ranges from reluctance to bitter opposition. In the main they have voted against the adoption of acceleration in the academic year of 1951-52. Needless to say, acceleration eliminates in large measure the opportunity for research and for the training of future teachers, and therefore it places our long-term medical progress in jeopardy.

We are driven to the inescapable conclusion that the most important thing we can do to increase the number and quality of doctors is to give more financial support to our medical schools. We allow them to languish and retrench for lack of a paltry $10 million—which was the medical schools' deficit in 1948. This in a country that spent more than $4,100 million on tobacco and smokers' supplies during that same year of grace! And two years later, with the financial clouds still darkening over medical education, a public fund appeal for $5 million for the schools that prepare our future doctors for practice finds difficulty in raising $1 million.

The essential fact is that the cost of medical education is a part of the cost of medical care. Perhaps we shall have to find out what a shortage of doctors really means before we realize the importance of supporting enough and good enough schools to prepare young men and women to meet our need for medical care.

Alan Gregg, physician, is Director of the Medical Sciences in the Rockefeller Foundation.

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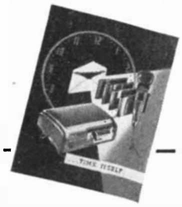

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The Synthetic Ion Exchange Resins

The process of ion exchange is transforming industrial and chemical processing, water conditioning, and even the treatment of congestive heart disease.

SINCE 1940, a whole new chapter has been added to the history of chemistry. It is a chapter which tells of many new industries, of improvement and simplification of older industries, and even of ways to help prolong our lives.

The brilliant Swedish chemist, Svante Auguste Arrhenius, prefaced the ion exchange story when he discovered the formation of positively and negatively charged particles (or ions), when acids, bases, and salts are dissolved in water. Even before Arrhenius, Joseph Spence, a Quaker pharmacist, had observed that ammonia from manure could replace calcium in the soil—by a process fundamental to plant growth. But it was not until 1935 that two British civil servants, B. A. Adams and E. L. Holmes, produced synthetic resins which would exchange, selectively, both positively charged and negatively charged ions. And it remained for an American manufacturer, Rohm & Haas Company, with long experience in related fields of resin technology, to develop the commercial possibilities of ion exchange with the products called AMBERLITE resins.

Just how are ions formed, and how do they behave in the ion exchange reaction?

Every chemical compound is composed of molecules—definite groups of atoms held together by electrical forces. Although these compounds may be decomposed into their atomic constituents, their properties are completely altered. For example, common salt decomposes into sodium, a very reactive metal, and chlorine, a green poisonous gas:

$$\underset{\text{Salt}}{2NaCl} \longrightarrow \underset{\text{Sodium}}{2Na} + \underset{\text{Chlorine}}{Cl_2}$$

If, however, sodium chloride is dissolved in water, a very different reaction takes place. Instead of *atoms*, electrically charged ions have appeared:

$$\underset{\text{Salt}}{NaCl} \longrightarrow \underset{\text{Sodium ion}}{Na+} + \underset{\text{Chloride ion}}{Cl-}$$

Now suppose that such a solution can be run through a sort of magnetic sponge. If the sponge is negatively charged, it will remove the sodium ions from the solution. If it is positively charged, it will remove the chlorine ions from solution. In ion exchange reactions, these ions actually are replaced rather than removed, but wide choice exists in the ions which are substituted for those originally in the solution.

Simply stated, then, ion exchange is the removal of ions from solution and their replacement with other ions. These ions may be removed because they are useful, and can be recovered economically through ion exchange; or they may be harmful, and may be removed through ion exchange for convenient disposal. Where essentially ion-free water is needed, the undesired ions may be replaced with hydrogen and hydroxyl ions, which merely unite to form more water.

THE instruments of commercial ion exchange are synthetic resins—chemical cousins to such plastics as PLEXIGLAS. A group of ion exchange resins working with high effectiveness in a wide range of applications is known as the Rohm & Haas AMBERLITE resins. AMBERLITE resins are bead-like particles, approximately ½ millimeter in diameter. Each of these beads is a storehouse for billions of ions. With proper treatment, the beads will release their ions, to waste or for recovery; and they then have the capacity to store more billions of ions. Since they are characterized by great stability, the resin beads may be used repeatedly without impairing their efficiency. An individual resin may be a strong base, a weak base, a strong acid, a weak acid, or a salt. This means that, through proper combination of the resins, AMBERLITE Ion Exchange can be made *selective*—performing *specific* tasks, with precision, time and time again.

It is in water-conditioning and industrial processing, that AMBERLITE resins find their greatest use. Water-softening heads the list. The replacement of "hard" calcium and magnesium ions with "soft" sodium ions is being accomplished efficiently and at low cost in thousands of American homes. Many municipalities partially soften water for entire communities. The City of Los Angeles, for example, employs ion exchange resins in the world's largest water-treating installation, to soften objectionably hard water from the Colorado River.

More and more power plants, too, need treated water supplies. For high pressure boilers, essentially ion-free water is a necessity—to avoid boiler scale, corrosion of equipment and reduced efficiency of steam turbines. AMBERLITE ion exchangers provide this deionized water—often in one pass through a single "Monobed" of mixed resins—for such companies as Iowa Electric Light & Power Co., Public Service Co. of Northern Illinois and Philadelphia Electric Co., one of the world's largest utilities. Where needed, commercial water containing less than one part of ionized solids in 100,000,000 can be prepared—a value heretofore obtained only through multiple laboratory distillations in quartz equipment.

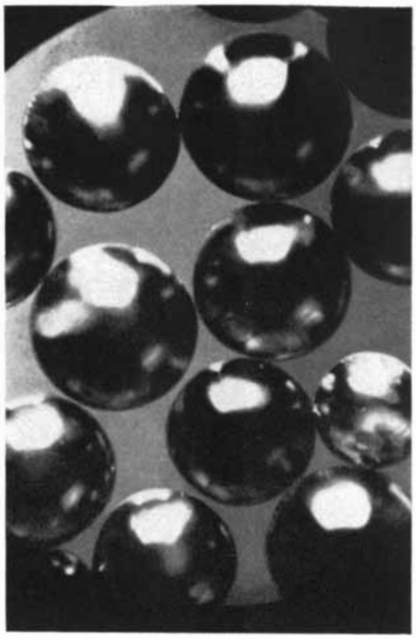
In industrial and chemical processing, the list of AMBERLITE uses is almost endless. Alcohol, amino acids, apple syrup, beet sugar, beverages, ceramics, copper, cosmetics, candy, dyes, gelatin, gold, ice—these are only the beginning of the alphabet of products *made possible* or *made better* by AMBERLITE ion exchange. The removal of formic acid from formaldehyde; deionization of sugar-bearing juices; refining of glycerine, sorbitol, and other polyhydric alcohols; removal of electrolytes from colloids; treatment of anodizing plating solutions; and the recovery of valuable wastes, precious metals, rare earths—these are a handful of the multitude of processes speeded and simplified by AMBERLITE synthetic ion exchange resins.

AMBERLITE deionized water plays an important part in the manufacture of pharmaceuticals. The removal of toxic substances—lead, mercury, copper, etc.—was an early accomplishment of ion exchange technique. Then came the successful isolation or purification of amino acids, vitamins, alkaloids, enzymes, nucleic acids, and carbohydrates. Exchange techniques, such as salt conversion, anion adsorption, and chromatographic separation facilitated the purification of the vital therapeutic reagents—penicillin and streptomycin. Indeed, over 90% of the world's supply of streptomycin is currently extracted from crude broths by an AMBERLITE resin!

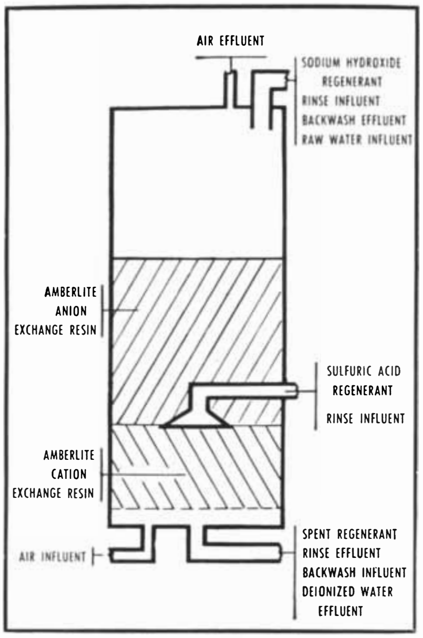
In chemical therapy, AMBERLITE resins also come into their own. Specially prepared AMBERLITE resins form the basis of acid-adsorbing drugs for the treatment of stomach ulcers. An adaptation of AMBERLITE resins systematically removes sodium from the body, preventing fluid from accumulating in persons suffering from congestive heart diseases and cirrhosis of the liver. These "plastic" medicines are also used in the treatment of certain types of diarrhea, and are being tested in cases of toxemia during pregnancy.

AMBERLITE resins also serve as analytical materials—for the determination of copper in milk, where the concentration of metal is extremely low—and for many other critical analyses. The effect of calcium on micro-biological culture media has been studied by means of the cation exchanger; and the effect of trace elements on the metabolism of plants has been examined. The determination of phosphorus pentoxide in rock phosphate has been accomplished readily by research grade AMBERLITE resins. Similarly, all traces of contaminating cations, such as iron, have been removed from the barium salt of adenosine triphosphate.

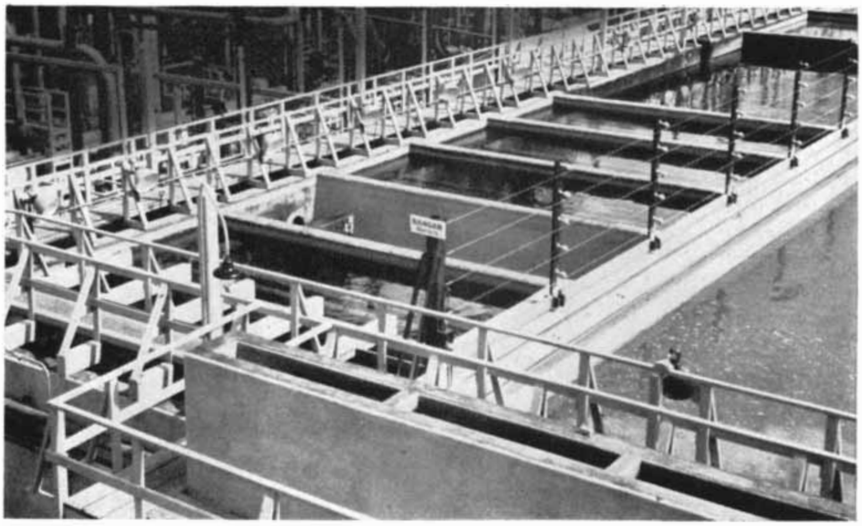
SINCE Adams' and Holmes' invention of the synthetic ion exchange resins, Rohm & Haas has, through its research and production facilities, pioneered in ion exchange chemistry and has pursued its theory and practice in many fields . . . literally from pills to power plants. As a result, Rohm & Haas today makes a very wide variety of synthetic ion exchangers—the AMBERLITE resins. If you would like full details of the AMBERLITE resins, you are invited to write to our Philadelphia Office. We shall be glad to send you complete information—without obligation.



Microscopic view of beads of AMBERLITE anion exchange resin. Each bead is capable of removing billions of ions from solution, and can be regenerated easily for reuse when exhausted.



Monobed—newest word in ion exchange—describes the method of using both anion and cation exchangers in a single bed. Water with electrical resistance of 20,000,000 ohms per centimeter can be obtained in one pass through one Monobed column.



AMBERLITE ion exchange provides deionized water for power plants of both industrial firms and public utilities. A continuous supply of water of assured quality is obtained.

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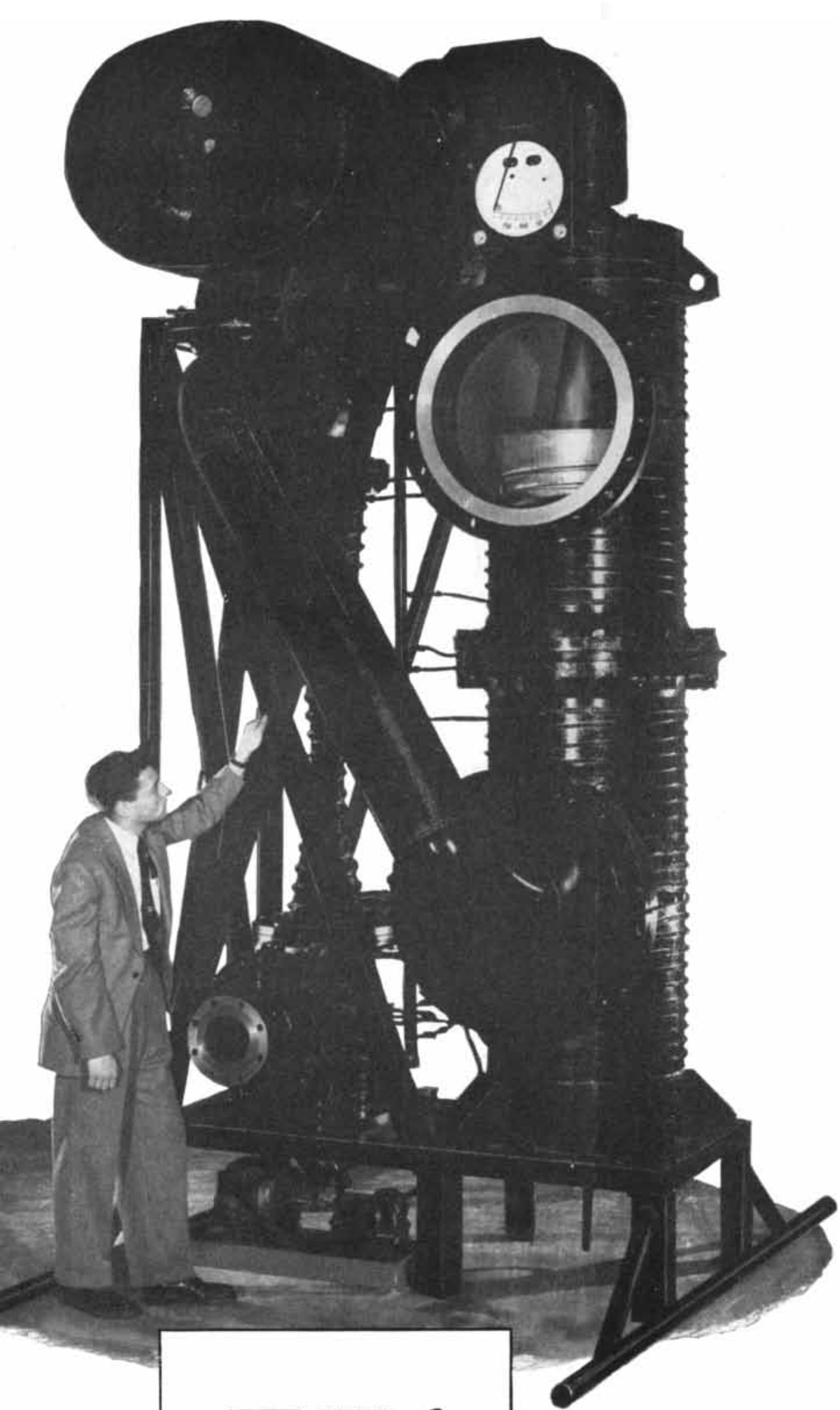

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MOBILIZATION

By 1952 we will have an armed force of 3.5 million. In the same time we must add 4.5 million workers to our arms production. Our biggest problem is to achieve this without weakening the nation

by Arthur S. Flemming

IN round numbers our manpower needs for the current program of defense mobilization can be stated simply. We must add 2 million persons to the working force in defense production this year and another 2.5 million in 1952—a total of 4.5 million. Most of these workers will be supplied by non-defense production, by the normal growth of the labor force and by the upward trend in the employment of women. We will nevertheless need 1 to 1.5 million "extra" workers.

At the same time we are providing for an armed force of 3.5 million, and recent comments by Secretary of Defense George C. Marshall indicate that the size of this force may be increased above the already authorized level. Can we mobilize this amount of manpower without weakening our economy or our long-term vitality as a nation? The answer to the question lies in how wisely and fully we use our resources. We can do the job we have set for ourselves, but it will take a great cooperative national effort to work out this crucial manpower problem.

We have seen no evidence so far of a general shortage of manpower. We are, however, already feeling the effects of shortages in certain highly trained fields, as other articles in this issue point out, and in certain geographical areas. It is these problems, rather than the total manpower situation, that will probably give us the most trouble.

Let us look first at the general picture. As we have indicated, of the 4.5 million new workers we shall need in defense production, a large number will be transferred into it automatically through the conversion of plants from non-defense to defense work. Plants making automobiles, refrigerators, washing machines, radio and television sets and the like will shut down for a few weeks, change production lines and then rehire workers for manufacturing defense items. But allowing for this factor, and for the growth of the labor force and the trend in the employment of women, how will we obtain the 1 to 1.5 million extra workers?

WE CAN FILL part of that deficit by making fuller use of women. We are not recruiting them as effectively as we might. During the war we drew large numbers of them into the labor force by emergency measures, such as providing centers for the daytime care of their children. Now, though we are in the middle of a new mobilization program, many employers do not feel the same necessity to provide incentives for women to take jobs. One way in which more women might be drawn into defense work would be to find ways and means to employ them part time. Many women who could not work a full 40-hour week might be very willing to adjust their schedules so they could work outside

AREAS OF LABOR SHORTAGE

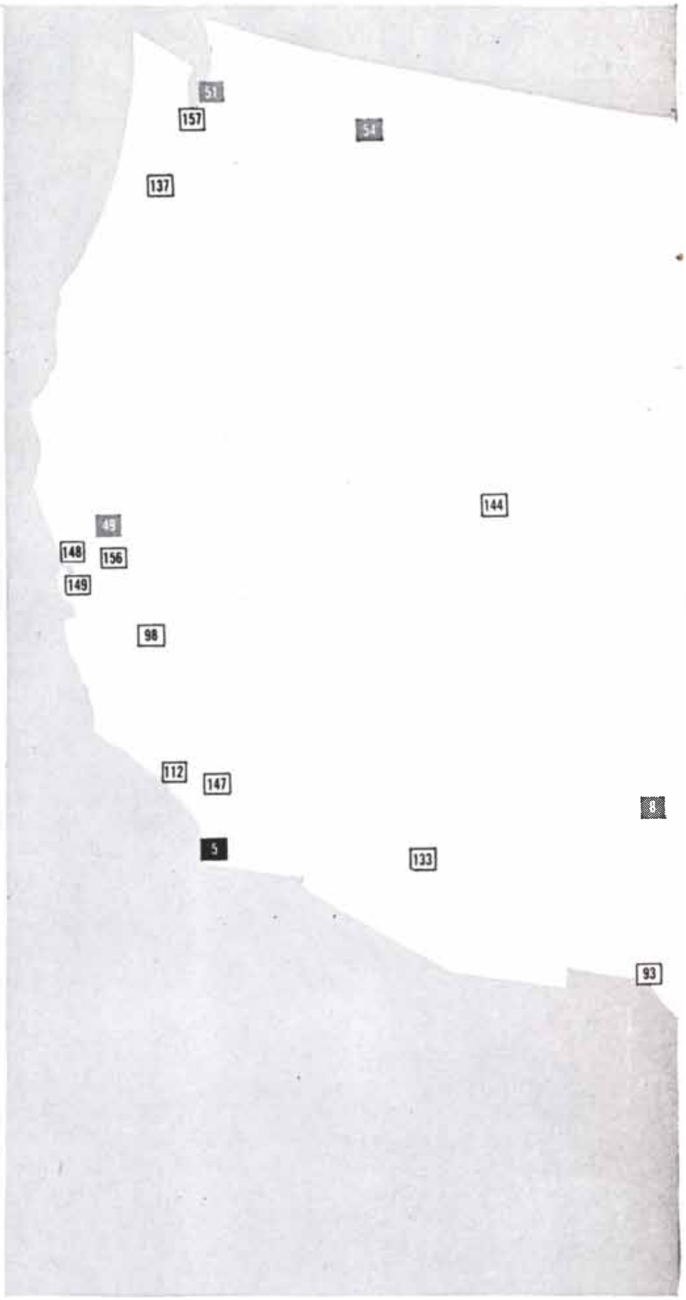
1 AIKEN, S. C.-AUGUSTA, GA.
2 DAVENPORT, IOWA-MOLINE, ILL.-ROCK ISLAND, ILL.
3 HARTFORD, CONN.
4 INDIANAPOLIS, IND.
5 SAN DIEGO, CALIF.
6 WICHITA, KAN.

AREAS OF BALANCED LABOR SUPPLY

7 ALBANY-TROY-SCHENECTADY, N. Y.
8 ALBUQUERQUE, N. M.
9 ALLENTOWN-BETHLEHEM, PA.
10 BALTIMORE, MD.
11 BINGHAMTON, N. Y.
12 BRIDGEPORT, CONN.
13 BUFFALO, N. Y.
14 CANTON, OHIO
15 CEDAR RAPIDS, IOWA
16 CHICAGO
17 CINCINNATI, OHIO
18 CLEVELAND, OHIO
19 COLUMBUS, GA.
20 COLUMBUS, OHIO
21 DALLAS, TEX.
22 DAYTON, OHIO
23 DENVER, COLO.
24 DES MOINES, IOWA
25 ERIE, PA.
26 FORT WAYNE, IND.
27 GALVESTON, TEX.
28 HAMILTON-MIDDLETOWN, OHIO
29 HARRISBURG, PA.
30 JACKSON, MICH.
31 JACKSONVILLE, FLA.
32 KALAMAZOO, MICH.
33 KANSAS CITY, MO.
34 LANCASTER, PA.
35 LINCOLN, NEB.
36 MACON, GA.
37 MADISON, WIS.
38 MILWAUKEE, WIS.
39 MUSKEGON, MICH.
40 NEW BRITAIN, CONN.
41 NEW HAVEN, CONN.
42 NORFOLK-PORTSMOUTH, VA.
43 OMAHA, NEB.
44 PERTH AMBOY, N. J.
45 RACINE, WIS.
46 RICHMOND, VA.
47 ROCHESTER, N. Y.
48 ROCKFORD, ILL.
49 SACRAMENTO, CALIF.
50 SAGINAW, MICH.
51 SEATTLE, WASH.
52 SIOUX FALLS, S. D.
53 SOUTH BEND, IND.
54 SPOKANE, WASH.
55 SPRINGFIELD, ILL.
56 SPRINGFIELD, OHIO
57 STAMFORD-NORWALK, CONN.
58 SYRACUSE, N. Y.
59 TOLEDO, OHIO
60 TOPEKA, KAN.
61 TRENTON, N. J.
62 TULSA, OKLA.
63 WASHINGTON, D. C.
64 WATERBURY, CONN.
65 WATERLOO, IOWA
66 WICHITA FALLS, TEX.
67 WILMINGTON, DEL.
68 YORK, PA.
69 YOUNGSTOWN, OHIO

AREAS OF LABOR SURPLUS

70 AKRON, OHIO
71 ALTOONA, PA.
72 AMARILLO, TEX.
73 ASHEVILE. N. C.
74 ATLANTA, GA.
75 ATLANTIC CITY, N. J.
76 AUSTIN, TEX.
77 BATON ROUGE, LA.
78 BAY CITY, MICH.
79 BEAUMONT—PORT ARTHUR, TEX.
80 BIRMINGHAM, ALA.
81 BOSTON, MASS.
82 BROCKTON, MASS.
83 CHARLESTON, S. C.
84 CHARLESTON, W. VA.
85 CHARLOTTE, N. C.
86 CHATTANOOGA, TENN.
87 COLUMBIA, S. C.
88 CORPUS CHRISTI, TEX.
89 DECATUR, ILL.
90 DETROIT
91 DULUTH, MINN.—SUPERIOR, WIS.
92 DURHAM, N. C.
93 EL PASO, TEX.
94 EVANSVILLE, IND.
95 FALL RIVER, MASS.
96 FLINT, MICH.
97 FORT WORTH, TEX.
98 FRESNO, CALIF.
99 GADSDEN, ALA.
100 GRAND RAPIDS, MICH.
101 GREENSBORO—HIGH POINT, N. C.
102 GREENVILLE, S. C.
103 HOUSTON, TEX.
104 HUNTINGTON, W. VA.—ASHLAND, KY.
105 JACKSON, MISS.
106 JOHNSTOWN, PA.
107 KNOXVILLE, TENN.
108 LANSING, MICH.
109 LAREDO, TEX.
110 LAWRENCE, MASS.
111 LITTLE ROCK—N. LITTLE ROCK, ARK.
112 LOS ANGELES
113 LOUISVILLE, KY.
114 LOWELL, MASS.
115 LUBBOCK, TEX.
116 MANCHESTER, N. H.
117 MEMPHIS, TENN.
118 MIAMI, FLA.
119 MINNEAPOLIS—ST. PAUL, MINN.
120 MOBILE, ALA.
121 MONTGOMERY, ALA.
122 MUNCIE, IND.
123 NASHVILLE, TENN.
124 NEWARK, N. J.
125 NEW BEDFORD, MASS.
126 NEW ORLEANS, LA.
127 NEW YORK, N. Y.
128 OKLAHOMA CITY, OKLA.
129 ORLANDO, FLA.
130 PATERSON, N. J.
131 PEORIA, ILL.
132 PHILADELPHIA
133 PHOENIX, ARIZ.
134 PITTSBURGH, PA.
135 PITTSFIELD, MASS.
136 PORTLAND, ME.
137 PORTLAND, ORE.
138 PROVIDENCE, R. I.
139 RALEIGH, N. C.
140 READING, PA.
141 ROANOKE, VA.
142 ST. JOSEPH, MO.
143 ST. LOUIS, MO.
144 SALT LAKE CITY, UTAH
145 SAN ANGELO, TEX.
146 SAN ANTONIO, TEX.
147 SAN BERNARDINO, CALIF.
148 SAN FRANCISCO—OAKLAND, CALIF.
149 SAN JOSE, CALIF.
150 SAVANNAH, GA.
151 SCRANTON, PA.
152 SHREVEPORT, LA.
153 SIOUX CITY, IOWA
154 SPRINGFIELD—HOLYOKE, MASS.
155 SPRINGFIELD, MO.
156 STOCKTON, CALIF.
157 TACOMA, WASH.
158 TAMPA—ST. PETERSBURG, FLA.
159 TERRE HAUTE, IND.
160 UTICA—ROME, N. Y.
161 WACO, TEX.
162 WHEELING, W. VA.—STEUBENVILLE, OHIO
163 WILKES BARRE—HAZLETON, PA.
164 WINSTON SALEM, N. C.
165 WORCESTER, MASS.



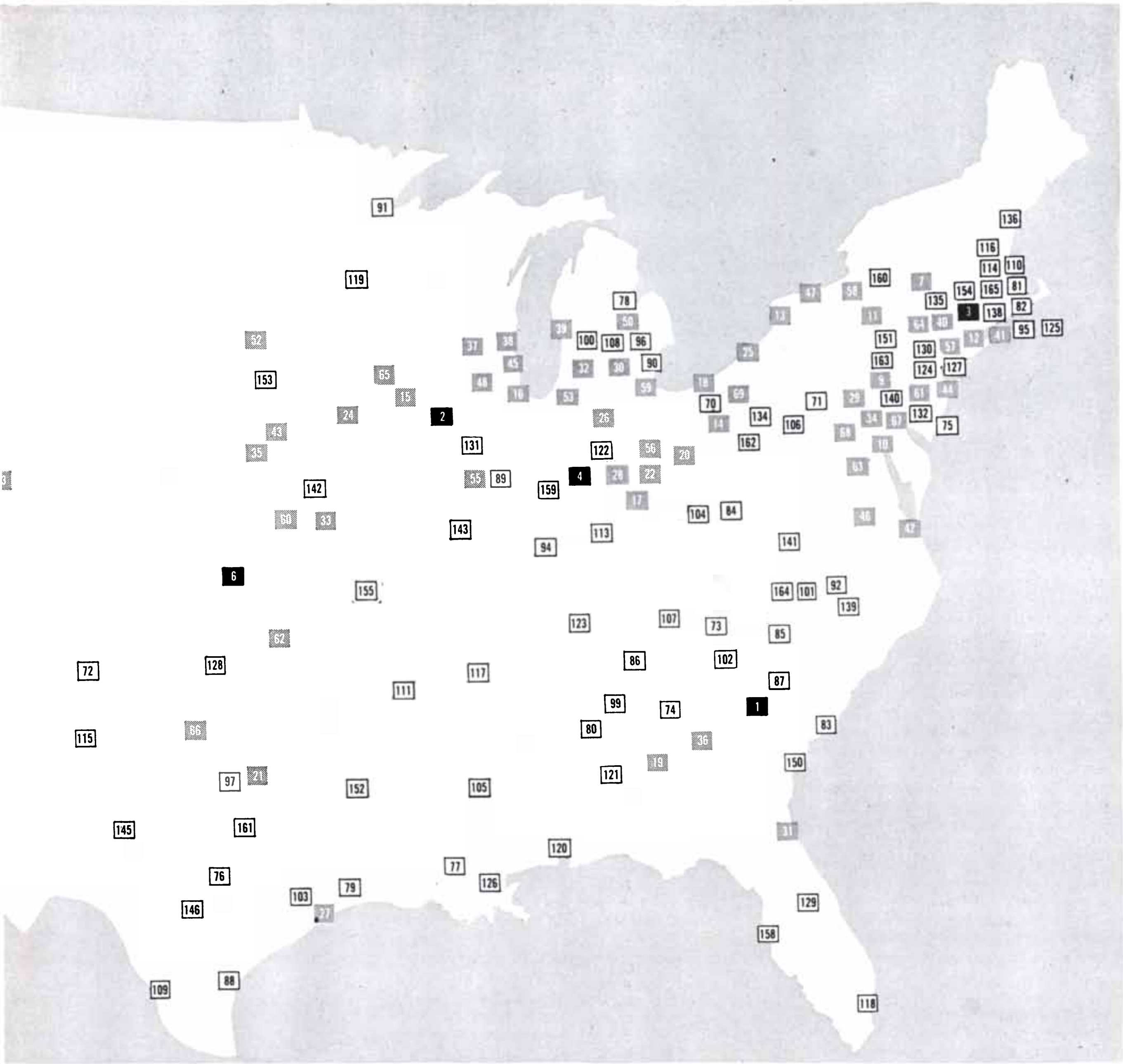
SUPPLY OF LABOR varies with the region. Indicated on this map are 165 places where there is either a surplus of labor (*white rectangles*), a balanced supply of labor (*gray rectangles*) or a shortage of labor (*black*

the home 20 hours a week, if industry made such jobs available to them.

Another large reserve from which we could get many more workers is the physically handicapped. Our World War II experience considerably reduced the prejudice among employers against hiring people with physical handicaps, for it showed that a person who has the faculties and abilities to perform a particular job is not handicapped so far as that job is concerned. A great deal of prejudice still exists, however, and the Office of Defense Mobilization has established a special task force to make recommendations toward the development of community programs for the more effective training and placement of the handicapped. It is estimated that the U. S. has at least 2 million handicapped persons who could be trained for useful work, and there are many others, already trained, who merely need help in finding places where their abilities could be used.

The older age groups offer another pool on which we can draw to fill our manpower needs. The wide adoption of pension plans is an obstacle to their employment, but there is no question that this obstacle can be removed. The matter is now receiving special attention from the National Labor-Management Manpower Policy Committee of the ODM, and we are convinced that it will be possible to develop a plan that will appeal to both labor and management.

Last but not least there is the large unused potential among our minority groups, especially Negroes. We made some progress in breaking down employment discrimination against them during World War II, but it is widely believed that we have slipped back since then. Certainly discrimination still exists, and



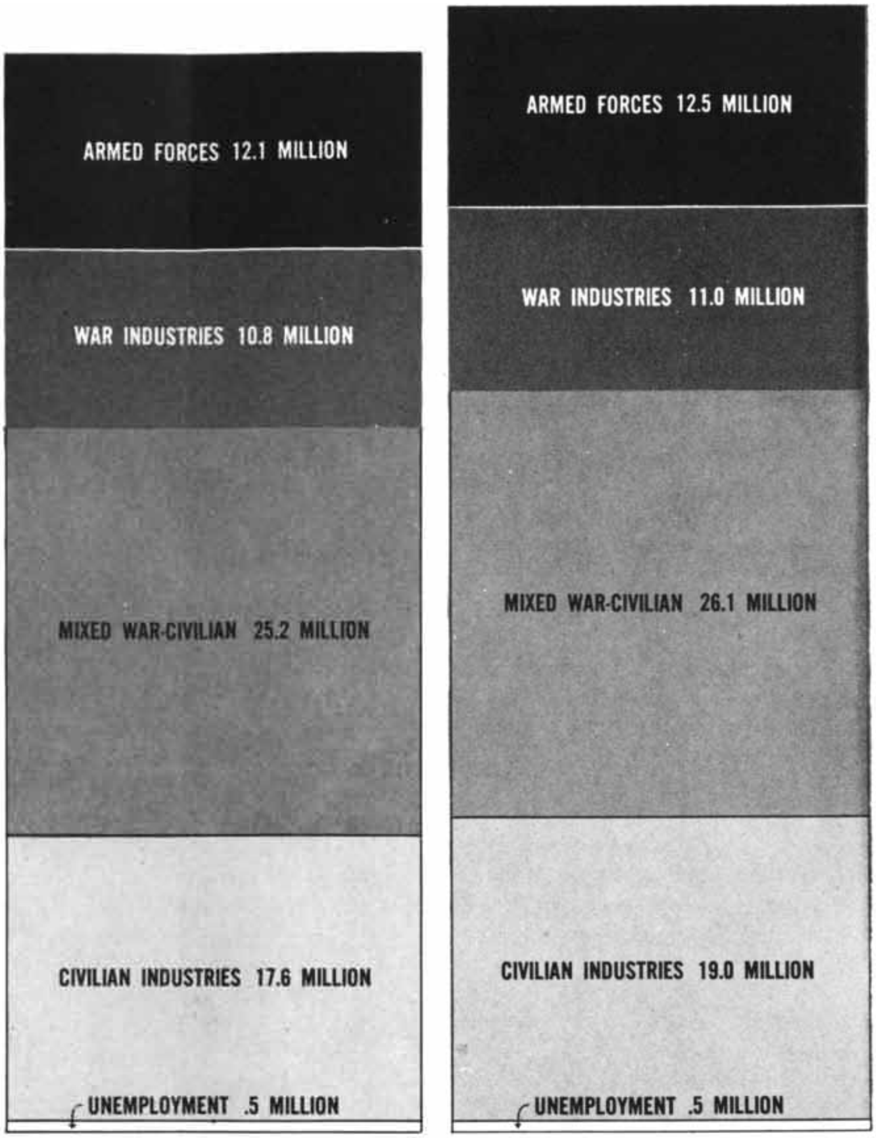
***rectangles*). The numbers on the rectangles are keyed to the names of cities at the left. An assessment of this kind makes it possible to avoid building plants or letting contracts in the areas where labor is short.**

it is a serious handicap in handling our manpower problem. By indulging in discriminatory practices we are deliberately refusing to solve some defense manpower problems that could be solved.

Summing it all up, if we do find ourselves up against a general manpower shortage, it will not be because a shortage actually exists but because we have failed to make the best use of the resources that are available to us.

LET US now consider the specific shortages. First there is the matter of local needs. The Department of Labor has already had to classify six places as areas of serious labor shortages from the standpoint of defense production. Two good examples are San Diego, Calif., and Wichita, Kan. There are several things that employers in such areas can do. They can examine their employment practices to see whether they are availing themselves of the extra sources of labor supply we have mentioned—women, the handicapped, older workers and minority groups. They can make sure that they are making the most effective possible use of the workers they already have. They can up-grade their workers to more skilled jobs by further training, either in their own plants or by cooperation with schools and colleges. The Consolidated Vultee Aircraft Corporation in Texas, for example, has an arrangement with Southern Methodist University whereby employees are enrolled in engineering courses and can actually earn credits toward a degree.

Employers in labor-shortage areas may also increase the working hours in their plants. The Office of Defense Mobilization has issued a statement dealing with this matter, with a warning that the lengthening of hours should not be car-



APRIL 1945 LABOR FORCE 66.2 MILLION — POTENTIAL LABOR FORCE 69.1 MILLION

FULL MOBILIZATION of our potential labor force (*column at right*) according to the pattern of World War II (*column at left*) might enable us to expand our presently planned armed forces from 3.5 to 12.5 million.

ried so far that it reduces productivity, as it did in some cases in World War II. The statement suggests that provisions for premium overtime pay should be kept as they are. This suggestion is consistent with the practice followed throughout World War II, and is based on the conviction that any other program would eliminate the incentive for overtime work. A change in overtime provisions would also require altering collective bargaining agreements affecting 15 million workers, and might lead to difficulties that would seriously interfere with defense production.

All these measures will help, but the best solution for the maldistribution of workers is to take care that the work is placed where adequate numbers of workers are available. This means that the factor of manpower supply must be taken into account in the location of new defense plants, in the expansion of existing ones and in the placement of contracts and subcontracts. Certainly no additional defense work should be awarded to areas that already have a critical labor shortage, except when it is impossible to place the work elsewhere.

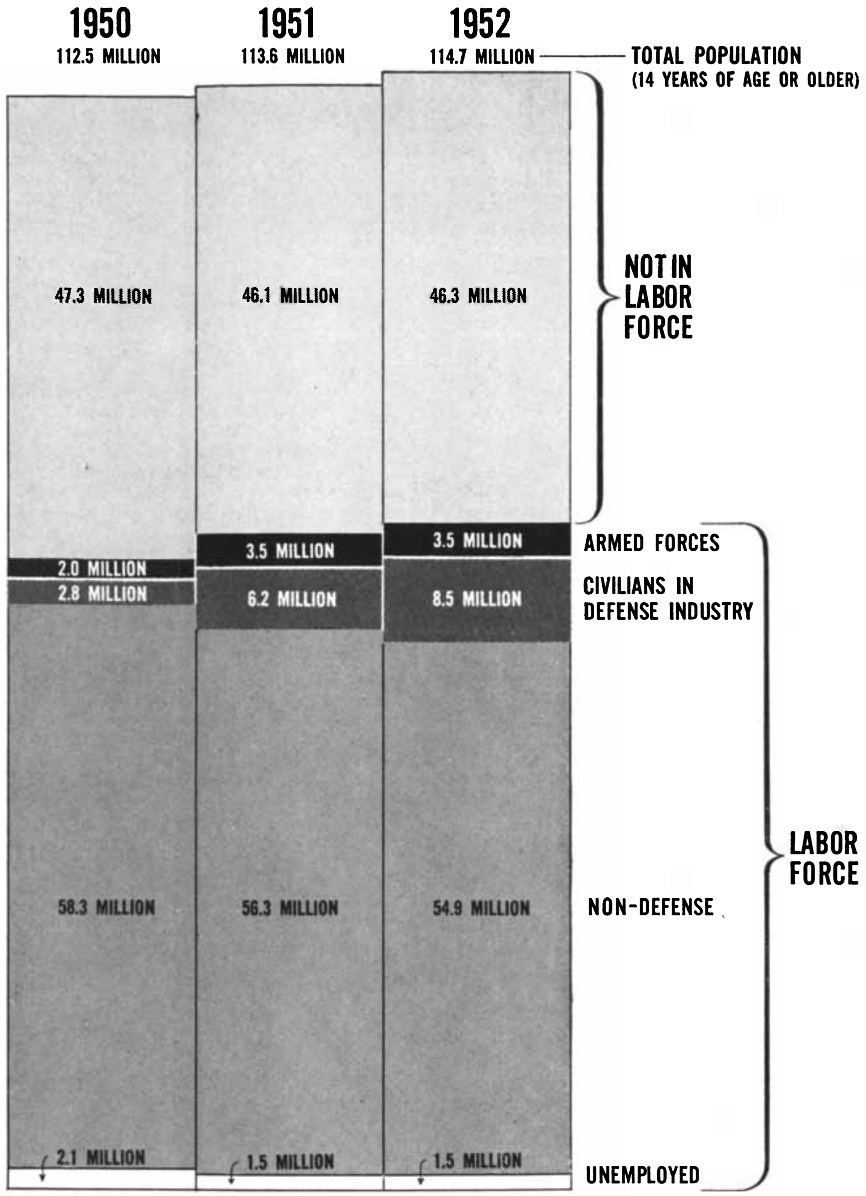
The ODM has issued a basic policy guide on this matter. It is designed to insure maximum use of the nation's total manpower potential by promoting full utilization of each area's manpower resources. The policies laid down are calculated to minimize the need for migration of workers and for diversion of manpower to build housing and community facilities for them. They also seek to hold unemployment to a minimum during the period of transition from nondefense to defense work; this is to be done through control of the allocation of materials. The policy instructs procurement officials to make a detailed study of the manpower situation in those regions which are designated by the Department of Labor as critical defense areas before awarding additional contracts, and it requires similar studies by the agencies responsible for the location and expansion of plants. These precautions should enable us to avoid many of the local manpower problems that arose in World War II.

During World War II we had to deal with some of our manpower problems on an industry-wide basis without regard to local conditions. Although this approach is not too satisfactory, we probably shall need to resort to it again in certain cases where the labor shortage is industry-wide. One such case is the machine-tool industry. The ODM has directed that manpower needs of this industry be given top priority by the agencies concerned. During the tooling-up stage of mobilization Selective Service and the Department of Defense will hold to a minimum their draft and reservist calls from this group of workers.

OUR shortages in the scientific and technical fields are discussed in detail elsewhere in this issue. Here I should like to mention certain general considerations that apply to the whole problem of providing an adequate supply of highly skilled manpower. We need to keep reminding ourselves that we are dealing with a long-term emergency. During World War II we did a great deal of improvising to meet shortages in trained manpower, assuming that the emergency would soon be over and that we could return to normalcy. This time we must deal with an emergency that may be with us for 10 to 20 years. Undoubtedly we shall again have to improvise to meet some immediate needs. If, however, we merely improvise and fail to work out long-range solutions, we shall certainly find ourselves confronted with problems that we cannot deal with effectively because we have begun too late.

First of all, we must make sure that we utilize our trained people for the work they are best fitted to do. Considering the shortages in these areas, and how important it is to the future of our nation and of the world that our defense program move forward according to schedule, it is inexcusable negligence for anyone in an administrative position, in or out of the Government, to fail to use the available personnel for the kind of work for which they have been trained. If an agency or organization has more trained persons than it needs in a category in which shortages exist elsewhere, it has an obligation to help place them where they are needed.

Second, counselors in our schools and colleges also should do everything within their power to persuade students with the necessary aptitudes to train for the occupations in which the demand exceeds the supply. Industry and the Gov-

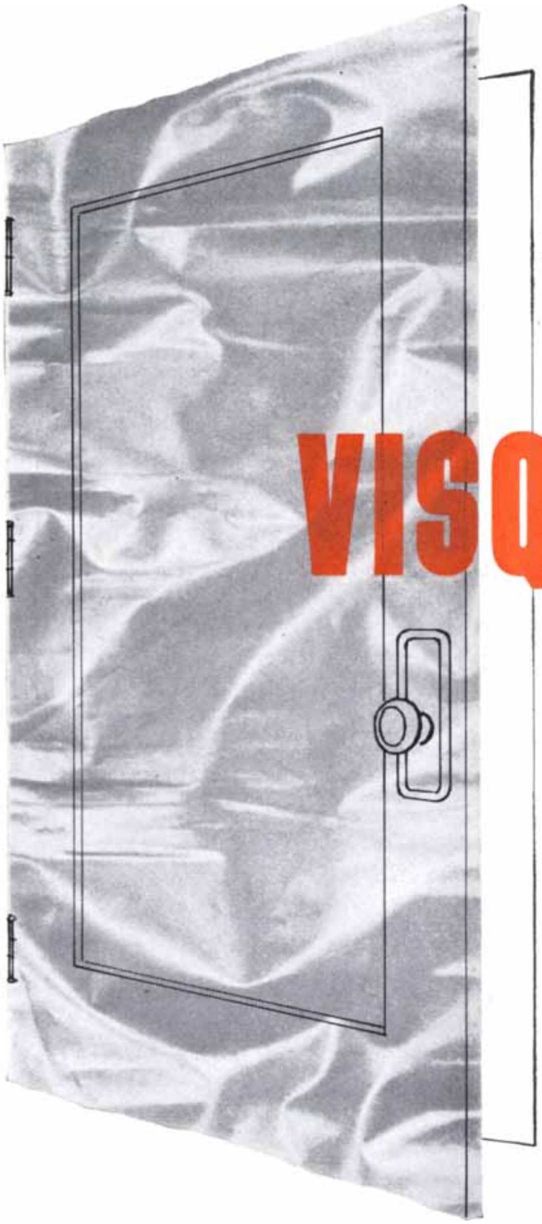


PROJECTED MOBILIZATION of a labor force that will support an armed force of 3.5 million should result in a labor force of 64.9 million by 1952. The figures in this chart are for the last quarter of 1950, 1951 and 1952.

ernment should see that the counselors are provided with facts about our manpower needs and opportunities. In this recruiting effort the women should not be overlooked. In many professional and technical fields we shall not be able to solve our manpower problems unless we use women to a greater extent than we have up to the present time. To do so we must convince them that training for these occupations will give them an unusual opportunity to serve the nation during a very critical period.

Third, the potential candidates for such occupations are not confined to the students in our schools and colleges. Among the workers already employed there are many persons who have aptitudes for scientific or technical work but lack training. We must discover them, and having discovered them, must be ingenious enough to develop ways and means of providing them with the necessary training without interfering with their present earnings. In many instances this means that employers and institutions of learning must display real ingenuity in working out such cooperative relationships.

HOW WILL the demands for military manpower affect those for civilian manpower? We are not yet in a position to say, because on some of the important questions the final decisions have not yet been made. Up to this point we have been planning on the basis of an armed force of 3.5 million men. Even on this basis we know that we shall have to cope with shortages in certain civilian occupations. We must now consider the implications of the proposal for further expansion of the military services. So far the proposal is only in the discussion



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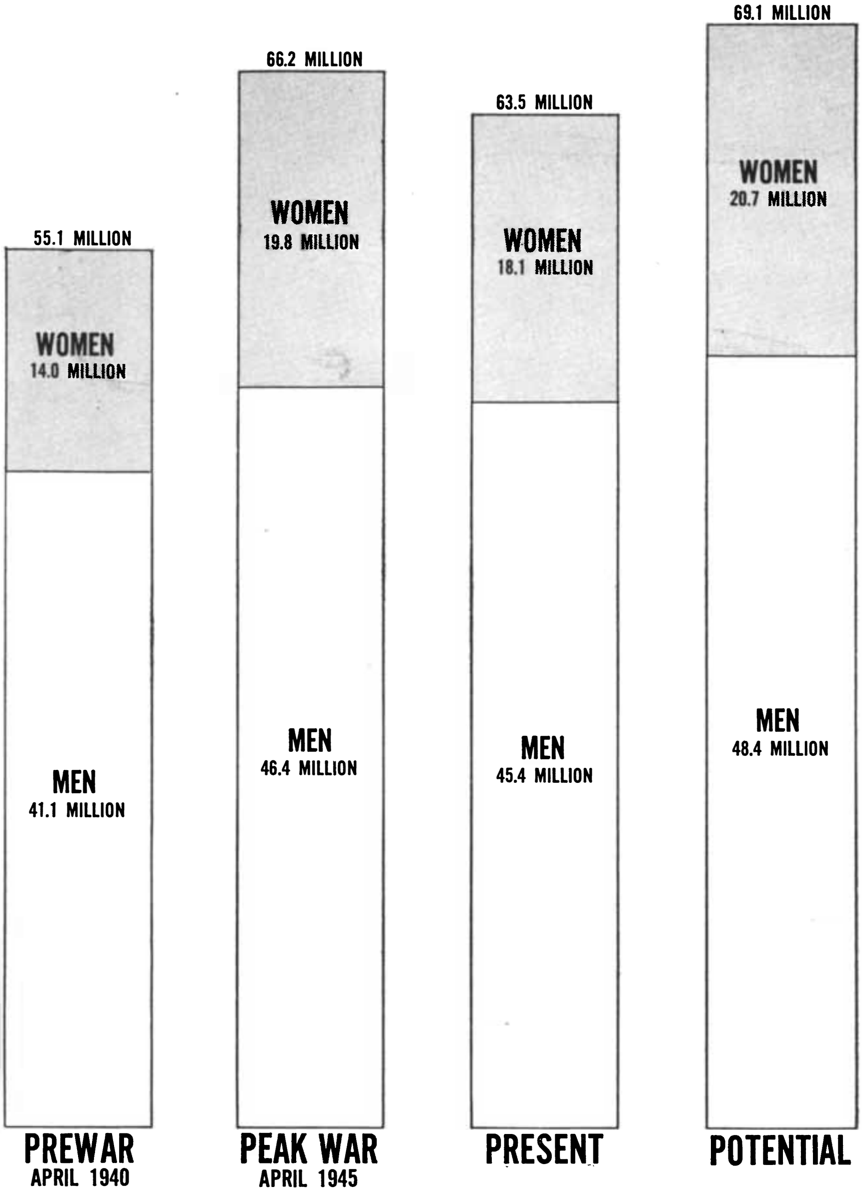

EMPLOYMENT OF WOMEN greatly increased during World War II and was a major factor in solving the manpower problems of that time. The continued high rate of employment has kept these new workers in the labor force.

stage, but the mere discussion of the matter underlines the importance of the problem. On one hand we must take account of the shortages of trained specialists in the civilian force that may interfere with production. On the other, we must recognize the needs of the military services for the same kinds of specialists. The working out of policies for deferments from military service is therefore one of the most important and difficult issues before the nation.

After considerable discussion a policy has been adopted for the postponement of the military service of certain college students during the academic year 1951-52, in recognition of the need for trained manpower. Local draft boards may defer induction of all students who receive a passing grade in a Selective Service qualification test or who rank in the upper three-fourths of men in the junior class, the upper two-thirds of the sophomore class or the upper half of the freshman class. If a local draft board refuses to permit a student who qualifies for this plan to remain in college for the coming academic year, he can appeal the decision through Selective Service channels.

When this plan was first announced, there were some vigorous objections. Many thought that the deferred students would escape military service altogether. Actually a large proportion of them will be called to serve in the armed forces as soon as they have graduated. It was objected that the plan gave preferred treatment to the comparatively small proportion of our capable youth who could afford to go to college. This point is well taken, but the best answer to it is not to reduce the supply of trained people but to see that more of our able

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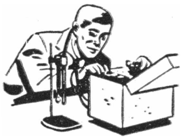

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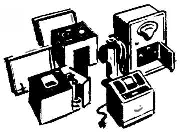

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youths are afforded the opportunity to attend college. If the plan for the postponement of military service for students in college is to continue in effect for any length of time, it seems clear that the Federal government must consider the possibility of developing a program for financial assistance to needy students. Such a plan is now being given consideration by manpower policy committees in the ODM.

DURING the next few months the nation will have to make some difficult decisions on these matters. The student-deferment plan in a sense is an interim measure; it may be revised by what Congress finally decides to do concerning a system of universal military training. The Congress is awaiting the report of a special commission on this subject. It is also considering some changes in the basic rules governing the recall of reserves by the Army, Navy and Air Force.

These and similar developments will have to be taken into consideration in the formulation of national manpower policies. Such policies will be determined only after the most careful study has been given the views of persons and representatives of groups of persons who have a vital part to play in the mobilization of our manpower resources on a voluntary basis.

An Inter-Agency Manpower Policy Committee established by the Director of the Office of Defense Mobilization provides us with the views of all of the agencies of the Executive Branch that have operating responsibilities in the manpower field. A Labor-Management Manpower Policy Committee provides us with the views of seven representatives of organized labor and a like number of representatives of industrial and agricultural management. In addition, the Secretary of Labor is in the process of appointing both regional and area labor-management committees.

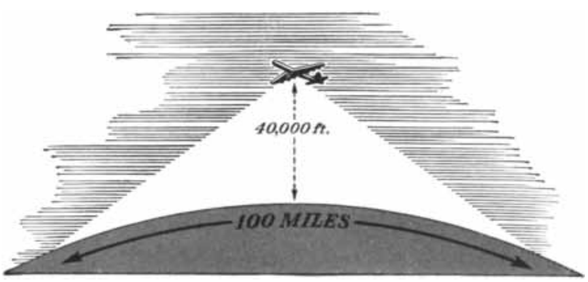
A Committee on Specialized Personnel will advise these committees on basic policies governing the training and employment of scientists, engineers, technicians and other types of specialized personnel. This Committee is made up of outstanding representatives of Government, industry, education and labor. A Health Resources Advisory Committee made up of recognized leaders in this area gives similar advice on problems relating to doctors, dentists and nurses.

A policy adopted as the result of the work of all of these groups will have a tremendous effect on the supply and utilization of trained manpower for years to come.

Arthur S. Flemming, educator, is Assistant to the Director (Manpower) of the Office of Defense Mobilization.

Behind the EYES OF RESEARCH

PUBLISHED IN THE INTEREST OF FURTHERING ANALYSIS AND RESEARCH THROUGH MODERN OPTICAL INSTRUMENTATION



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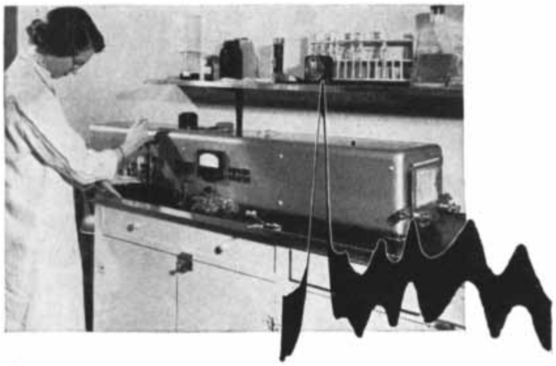

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What lies beyond the full utilization of our human resources? Our best hope is to increase our educational opportunities and enlarge the fraction of our people capable of learning the higher skills

by George D. Stoddard

IT IS CLEAR that extraordinary demands will be made on the human resources of the U. S. in the coming years. There are shortages in trained personnel. There are shortages in the educational facilities that turn out the trained personnel. Is there also a shortage in human raw materials? Can we lengthen the period of schooling without a diminishing return? Are there enough geniuses and subgeniuses to maintain our social structures at ever-more-complex levels? Can our human stock stand the strain of the intellectual demands that the overwhelming danger of atomic warfare places upon all of us?

Let us leave out the question of our physical and artistic capabilities, for they are more or less irrelevant. We know how to keep ourselves in good physical condition, but that is not enough. And the artist cannot save us; he can only help to make us worth saving. Who, then, can save us? Only persons who possess the necessary knowledge and leadership ability. Natural resources become human achievement through the work of the scientist, the technologist and the professional worker in a dozen lines. Of course, leadership in a vacuum is not enough. Without the backing and the sustained good will of citizens who are dedicated to ideals held in common, nothing would avail. If the social organism is to survive, we need both the head and the body. The new competition is not simply for economic goods, for territory, for an excess of military might. The deep struggle is for the minds of men.

The U. S., justly famous for its processing of natural resources, its ability to produce and distribute, is called upon to make two additional contributions to the world. The first one, which Americans have been making almost unconsciously since 1776, is the lift to liberty and freedom given in our declarations of the rights of man. The U. S. was the first nation to be formed as a direct outcome of democratic principles, and although there are some defects in our practice, particularly in regard to the rights of minorities, we have not wavered in our general adherence to these great doctrines.

The second call upon the U. S. is one that European cultures acknowledge with reluctance: it is to furnish leadership in the world of the intellect. Whether we like the role or not—and many persons do not—America is the new Greece and the new Rome. Consider as a single indestructible symbol the fact that Albert Einstein chose the U. S. as his home—and prospered here.

All this rests upon a discovery largely our own: namely, that talent exists in every social level of the population, indeed, that at birth it is about evenly distributed in all levels. America has tried "to give every one a chance." In so doing, we struck rich ore: it turned out that nearly everybody deserved this chance to make good. Our great cultural inventions—such as the public school, the land-grant college, an effective tax system and a social structure almost devoid of class barriers—combined to produce something the world sorely needed: the emergence of talented leaders and

the most universally educated citizenry in history. Old cultures had foundered on the fallacy that the elite alone should rule. Americans escaped the trap by happy circumstances that led first to a demand for literacy and then to its sequel in easily accessible institutions of higher learning.

THE conclusion that everyone is worthy of the chance to make good deserves a little closer attention. Probably many readers are acquainted with the study of children's intelligence that was carried out at the Child Welfare Research Station of the University of Iowa during the 1930s and 1940s. It was an examination of the mental growth of more than 100 children who had been placed in good foster homes as infants. They were all children of mothers low in intelligence and economic and social status. Their foster parents, however, gave them the careful upbringing and good schooling that middle-class children receive.

Psychologists at the Research Station measured the intelligence of 100 of these children at four stages—roughly the ages of two, four, six and a half and thirteen and a half. In the last report on this investigation two years ago, called *A Final Follow-Up Study of 100 Adopted Children*, Marie Skodak and Harold M. Skeels confirmed what the earlier reports had already indicated: that these children of mentally inferior mothers, given good care and schooling, scored well above average in intelligence. Their median I.Q. at the four ages when they were tested was, respectively, 117.5, 111, 114.2 and 107.9. (These scores were based on the old Stanford revision of the Binet-Simon tests; on the last test the children were also examined by the new—1937—Stanford revision, and their median score on the latter was 117.2.) Some of the children were very bright indeed: the four highest scored 152, 145, 142 and 141. Only 10 of the 100 children had I.Q.'s below 100.

The remarkable thing is that as a group these children far surpassed the I.Q. level of their true mothers and fathers and the level reached by average children in the U. S. The final median I.Q. of the children (117) exceeds by 17 points the I.Q. of the average U. S. child.

THE psychological and social implications of these results are clear. In the first place, they prove that we cannot measure the mental ability of children through measurements of their parents. Every newborn child receives a new pattern of genes. The only reliable way to discover how good this pattern may be is to measure directly the growth of the child under favorable circumstances. Studies show that when children of the same type of parentage as those in the Skodak-Skeels study are kept in poor homes or poor orphanages, they do not improve but tend to decline in mental ability.

In brief, the theory that a child is tied to the mental level of his parents is no longer tenable. A child born to a secure family, sent to a good school and exposed to a high level of aspiration approaches maximum mental power. The same child, placed in degrading, frustrating situations, will approach a minimum. The structure of the brain allows for a wide range of delivered mental ability.

Mental efficiency—intelligence as we measure it—is a product of inherited factors, the age, experience and physiological development of the individual and the adequacy of the culture in which he grows up. Thus there is an inevitable correlation between environmental factors and intelligence. One way to reduce intelligence is to keep the child culturally impoverished; by the same token one way to increase it is to provide enrichment. Other factors that play a part in the rate of mental growth are emotional involvements, diseases or injuries of the nervous system and growth and deterioration related to age.

What an intelligence test measures is vocabulary, definitions, meanings, solutions to problems, reading comprehension and the like. From the individual's performance on the test an estimate of the inherent capacities of his nervous system is inferred, but it is impossible to separate these from the cultural factors. Moreover, aside from the impossibility of distinguishing the genetic from the cultural factors, present-day intelligence tests are defective with respect to the measurement of high-level abstracting powers, the ability to overcome emotional blockages and the ability to solve problems through creative imagination. A test of general intelligence needs to be supplemented by other measures, such as tests of character, personality and special abilities.

IT FOLLOWS from all this that the key to the fuller utilization of our human resources is to provide more enrichment—to give each person the best possible education. This means, as the first step, better schools and colleges, with larger enrollments. What should be the goals of this education?

Surely one of the prime needs is what John Dewey has called social intelligence. It took brains to produce the atomic bomb. It will take still more brains to avoid its suicidal use. What is called for is a new intelligence based on social science and a new support of social science by the public.

In the social sciences communication and teamwork between the expert and the intelligent citizen will need to go beyond anything needed in physical science. Almost everybody is willing to remain ignorant, and silent, regarding

advanced mathematics. But concerning psychology, education, sociology, history, political science and religion almost nobody remains silent, whatever his ignorance or erudition. It is not easy to change this human trait. The difficulty is that in general education, dealing with the social problems that concern us all, we must rely chiefly on common symbols—on words—rather than the precise tools and symbols available to the natural scientist. And a mere verbal facility with ideas is a form of intellectual sterility. It creates the impression of learning without its counterpart in thought. Now that it has become so easy to lift ideas out of a newspaper column or a radio or TV program, the pseudo-thinker assumes the proportions of a menace. He always was a bore.

It is the business of the school or college to provide the genuine article. The aim of higher education is not to turn out "educated" men and women, emerging bright and shiny like so many insects from a four-year cocoon. The aim is rather to give students a living fund of knowledge from which they may generate ideas and to encourage straight thinking. The essence of college life is learning—independent learning—on the part of the student. He is not there to be told something, to be sold something, or to be shown something by way of amusement. He is there to get ideas—or reject them—straight, uncolored and uncorrupted.

If our colleges are free and honest as guides to youth, this does not necessarily mean that what they teach, or the way they teach it, will have the desired effect upon immature minds. Learning is a subtle process. What are the general principles and the practical limitations that affect it?

We know that the time factor is important in learning. The mathematical genius who startles the world with unique ideas at the age of 21 may have been steeped in mathematics for 15 years. John Stuart Mill was started on his involuntary study of Greek and Latin by his father in the preschool years. (Fortunately for the ego satisfaction of his father, the boy's nervous system was equal to the task.) The principle is that we learn by being placed in learning situations. We learn not by doing, but by thinking about what we are doing. To choose to go to college is to say that one has more confidence in what it can do than in casual and perhaps misdirected activities. The college underlines a sense of future, of preparation, of purpose.

To some extent the conditions of learning determine its effectiveness. Learning is not something poured over a person like a rich sauce. It penetrates his cells; it shows up in what he knows, does and is. A college graduate is not only different from what he was when he entered—he is different from what he could

have been without college. Generally the difference is in a favorable direction.

What we seek finally is complete freedom in thought combined with optimum freedom in action. That is the dual basis for comprehension and discovery. One test of the outcome is found in the power to communicate. A person who is clear in his mind can make his mind clear to others. To the ready and free mind beliefs do not come suddenly and with certainty; they grow. This evolutionary process depends upon access to organized facts, but it also implies critical evaluation. That part of one's education which is beyond mere memory takes place in areas of conflict.

Surely there is ever more to know. The world of the intellect, like the universe itself, is expanding. We can be as bogged down in a deluge of words and images as a dinosaur in his asphalt swamp. We must choose and choose wisely if the human brain is to remain useful. The call is, and will always be, for selection and integration. The process is not one of accretion. It is organic and evolutionary. All depends on whether the evolution is in a constructive or destructive direction. It takes five years of expert conditioning to make or break the habit of thinking. It takes less than five minutes of drug, shock or radiation to ruin the nervous system.

WHO should go to college? The report of the President's Commission on Higher Education in 1947 told the story in a nutshell. It found that, on the basis of comparative scores in the Army psychological tests, at least half of our youth population has the mental ability to succeed in school through the junior-college level and at least a third of the population could go beyond that to complete four years of college.

How many do go to college? About 20 per cent—one out of five of college age. We could have twice as many in college at a given time without dropping below the level of mental ability necessary for academic success. It is true that only half the present college population earns a college degree, but the student body is not drawn entirely from the upper reaches of intelligence—far from it. As Dael Wolfle has shown, the number of youths with college ability outruns college graduation by over four to one.

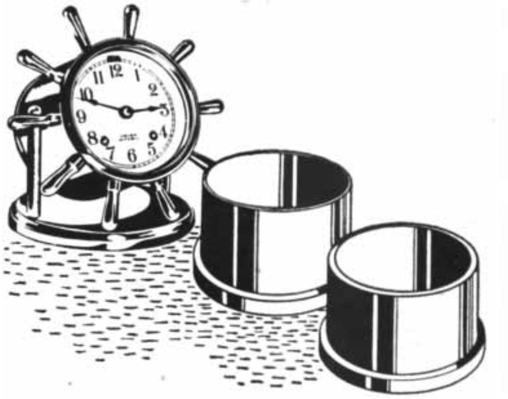
Does the nation want youth in college in greater numbers? This question was answered by a *Fortune* magazine poll two years ago. It asked a cross section of America: "If you had a son, would you want this son to go to college?" Eighty-three per cent said Yes. Even when the parents were asked what their answer would be if the son were not very intelligent or interested in college and the money were not in sight, 62 per cent still said they would want him to go to college. (For girls the insistence was somewhat less.) Going to college is a

BUSINESS IN MOTION

To our Colleagues in American Business . . .

War is notorious for wasting lives, money and materials, but, it is also responsible, at times and in a somewhat indirect way, for progress in scientific and practical matters that eventually are turned to valuable peace-time applications. A few such by-products are rather widely known; atomic energy, for example. Recently there has come to Revere's attention an instance that is much less important and spectacular but which is worth discussing. It might be called "the case of a case."

During the war, one of Revere's customers made 4.5 howitzer cases out of cartridge brass. The case was $3\frac{3}{4}$ inches high, with an outside diameter of $4\frac{3}{4}$ inches. The walls were thin, and the base thick. Integral with the base was a heavy flange, $\frac{1}{8}$ inch thick. Inside, the base was $\frac{1}{4}$ inch thick. Since the case had to be a single piece of brass, the flange had to be generated by flowing the metal from the base after the preliminary cupping operations. Many problems were solved in the successful production of this case, in connection with the metal, tools, lubricants and production controls. This particular firm developed procedures that were somewhat unusual, which speeded production, realized economies, yet met strict specifications.



After the war, this Revere customer was asked by a clock company if it could cold-form clock cases out of brass, the purpose being to replace a heavy casting with a lighter stamping. Drawings of the clock case showed its dimensions to be close to those of the howitzer case, and in other respects the similarities between the two were striking. The most important difference was that the large radius on the inside of the howitzer cases was not permissible for the clock, because of the space required for the works.

In order to provide a thinner base, and one that was flat both inside and outside, only a few manufacturing changes had to be made. The knowledge acquired during the war was applied. The bottom design was achieved by squaring the case to the exact height, providing the bottom knockout with exactly the correct amount of spring tension in the restrike, and carefully governing the pressure and speed of press travel. If this sounds complicated to the average reader, it was simple to the men who had made millions of cases for war. They coordinated all the factors, produced perfect clock cases, and thus provided another example of the adaptation of a war product to a peaceful use. The case is handsome, accurate in all dimensions, and costs only about a third as much as the previous case, which was a machined casting.

Let us hope there's not another world war, but if there is, remember that suppliers in all lines will learn something new. And do not forget that the firms from whom you now buy, no matter what it is, may have new knowledge that may save materials and reduce costs, in these days when it is so important to do both. Inquire of them what they can do for you that is new. Instead of merely duplicating previous orders, ask your suppliers what they have, or know, that could be of value to you. The results may surprise you very pleasantly indeed.

REVERE COPPER AND BRASS INCORPORATED

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Executive Offices:

230 Park Avenue, New York 17, N. Y.

SEE "MEET THE PRESS" ON NBC TELEVISION EVERY SUNDAY part of our social mores. Increasingly those youths who do not go to college will carry a burden of proof as to their ability, drive or thrift.

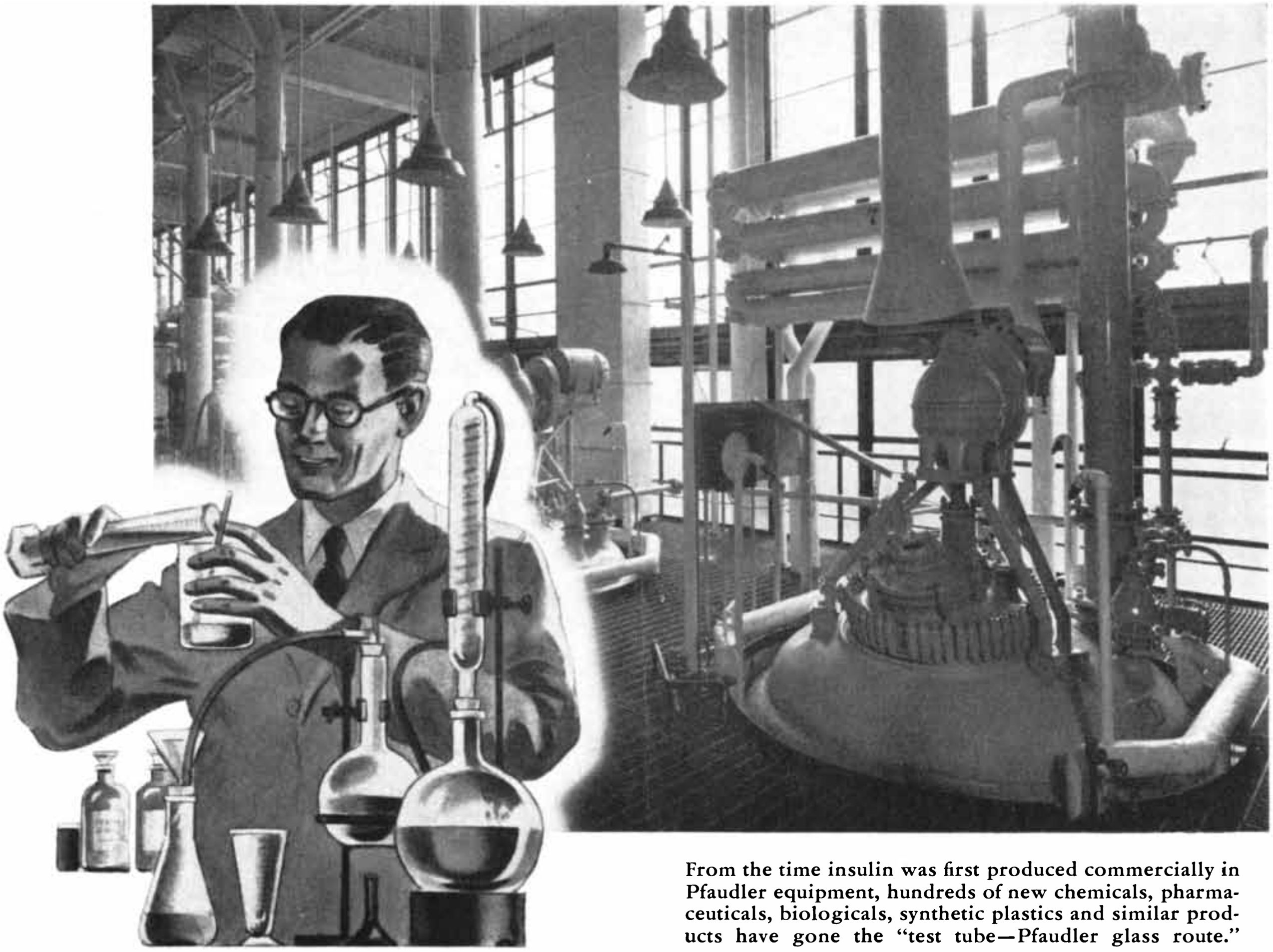
In short, the talent exists, the people are for it and the U. S. position in the world demands a tremendous upsurge in the number of persons in college. The lag is in facilities and money, but there is nothing unusual about that problem. If we can provide the money for airplanes, tanks, armies, navies and atomic bombs, we should be able to provide it for higher education. The return would be as great or greater; for education, unlike a bomb, is in itself a producer of new goods and services. The bomb is at best an insurance against the horror of itself turned upon us. Education is insurance *plus*—plus the heightening of conditions and experiences that give life more savor.

THE discovery and full development of the talent of our youth is crucial to our defense. It is a condition of our sustained leadership. We cannot match our potential enemies in sheer numbers, but we have the kind of social and political system that enables us to surpass them in the free and full cultivation of our people's intellectual capacities. It is no part of democratic doctrine to waste talent or to encourage the pseudo-luxury of its non-development. We shall prosper as we relate talent to the continuing needs of a free society.

Totalitarian systems tend to suffocate thought. The Russian experiment, like fascism and nazism, does not free anybody. It does not offer a new way of life, but an old, hardened way by which liberty is laid on the counter in exchange for a dry rot of words. With the hypnotism of words there enters one of the most ancient institutions, slavery—physical slavery for some, mental slavery for all. Thus the Iron Curtain works both ways, and not altogether against the free world. Intellectual defeatism may prove to be more deadly to the Soviet system than external enemies.

Let us, therefore, take heart! The U. S. is under no compulsion to change its basic ways. It is still good to proclaim, and to establish, the rights of man. It is still good to grow, to keep the pioneering spirit, extending it mightily in the realm of the sciences, arts and humanities. As we look at the facts of life in America, we may come away not with a sense of grave errors and mistaken philosophies, but quite the reverse. The raw materials of life are good and the good genes are to be found everywhere. A new realization on our part of the utter inseparability of heredity and environment may help the next generation to find higher ground.

George D. Stoddard, educator, is President of the University of Illinois.



From the time insulin was first produced commercially in Pfaudler equipment, hundreds of new chemicals, pharmaceuticals, biologicals, synthetic plastics and similar products have gone the "test tube—Pfaudler glass route."

BOOKS

Concerning the psychological test, a tool for the measurement of human resources

by Henry S. Dyer

ESSENTIALS OF PSYCHOLOGICAL TESTING, by Lee J. Cronbach. Harper and Brothers ($5.00).
PERSONNEL SELECTION, TEST AND MEASUREMENT TECHNIQUES, by Robert L. Thorndike. John Wiley & Sons, Inc. ($4.00).
APPRAISING VOCATIONAL FITNESS BY MEANS OF PSYCHOLOGICAL TESTS, by Donald E. Super. Harper and Brothers ($6.50).
ASSESSMENT OF MEN, by the Office of Strategic Services Assessment Staff. Rinehart and Company, Inc. ($6.50).
EDUCATIONAL MEASUREMENT, edited by Everet F. Lindquist. American Council on Education ($6.00).

IN THE mobilization of manpower for World War II one of the problems was to find among men in ordinary civilian pursuits those who were capable of being trained to handle military specialties requiring, in many instances, a high degree of technical competence. The problem was met, on the whole successfully, by an extensive program of psychological testing. The testers learned a good deal from this experience, and the question arises whether tests have not got to a point where they can furnish important solutions to the nonmilitary manpower problems now facing us.

The five recent books reviewed here reflect what is going on in the various branches of psychological testing and outline what can be expected of it. The authors of the books, however, give one the general impression that there is no simple answer to the question raised above. If one asks whether the tester can reach into his files and pull out aptitude tests that will unerringly locate people with good prospects for the law, medicine, engineering, teaching or scientific research, the answer is a simple no. But if one asks whether the psychologist has any fruitful notions about how to attack the problem, the answer is a cautious yes. Given certain conditions he can usually find or devise tests that will substantially reduce, but not eliminate, mistakes in picking the right person for the right job. The difficulty lies in bringing about the conditions.

Among these books the most comprehensive treatment—and one that assumes no technical background in psychology or statistics—is *Essentials of Psychological Testing,* by Lee J. Cronbach. Although the book is elementary in character, it will give the reader an insight into all the fundamental concepts of psychological measurement. Cronbach tends to side with those test technicians who favor a controlled empirical approach to the description and prediction of human behavior, but at the same time he gives full recognition to the work of clinical psychologists and vocational counselors who, in the practical application of testing instruments to their clients, find it necessary to rely heavily on their own intuitions.

The book begins with a preliminary section intended to give the reader an understanding of technical matters sufficient to enable him to follow the ensuing discussion. It then provides helpful descriptions and shrewd analyses of tests, representing all the major types from the old-fashioned intelligence tests to the so-called projective tests, which purport to find the individual's total personality in his response to ink blots. Cronbach has reservations about each of the tests he discusses, and takes pains to document his doubts. Nevertheless he presents a wealth of evidence to show that psychological testing has made significant contributions in the past and has impressive possibilities for the future.

Robert L. Thorndike's book, *Personnel Selection, Test and Measurement Techniques,* discusses a more narrowly defined field. Although psychological measurement is at best a complex and uncertain business, there is one problem that it is reasonably prepared to handle. This is the problem of choosing people

for specified jobs in some particular organization, and it is this problem with which Thorndike deals. Under such conditions the job requirements are, or can be, operationally defined, and the effectiveness of any test used to choose people for these requirements can usually be checked against actual experience. Statisticians, as Thorndike shows, have evolved some powerful techniques for coping with the situation, but the elements of the procedure are simple enough: they consist of (1) analyzing the job to see what activities are characteristic of those who work at it; (2) putting together a group of tests that on *a priori* grounds seem capable of predicting who will do the job well and who will not; (3) giving the tests to a large group of individuals who are about to be employed or trained; (4) determining after a period of time how well these people are doing; (5) comparing each individual's performance on the job with his performance on the tests; (6) determining from the data thus obtained how to combine the tests so that they will best separate the potential successes from the potential failures. In brief, the tests are custom-built to fit the demands of the particular situation. In these circumstances the fit, though not perfect, is likely to be satisfactory.

Thorndike goes into each phase of the process, describes the technical problems that are likely to be encountered along the way, and discusses various methods of handling them. To illustrate his points he draws heavily on his experience in the Aviation Psychology Program of World War II, and although the problem of selecting men for the Air Force is not exactly the same as the problem of selecting men for jobs in private industry, Thorndike is usually successful in showing how solutions found in the one can be applied to the other. Possibly the chief weakness in the argument is that while many of the techniques described in the book envisage hundreds, or even thousands, of trainees on whom to try the tests, the average private employer, especially when he is concerned about selection for high-level jobs, may have a scant dozen available for study.

Appraising Vocational Fitness by Means of Psychological Tests, by Donald E. Super, approaches the same problem from the opposite end: instead of describing how tests are used to find the right person for a particular job, he shows how they are used to find the right job for a particular person. The change in focus increases the uncertainties a thousand-fold. Not all jobs bearing the same label make the same demands on the people who work at them. A test that may be helpful in predicting the success of chemists in one company may be useless in predicting the success of chemists in another. And there are practically no dependable research findings that can be used as a basis for determining an individual's relative chances for success in one job as compared with another.

In a thorough survey of the literature on all the important vocational tests, Super demonstrates the difficulties that the vocational counselor faces in trying to extract meaning from them: the lack of data about tests and job requirements, the inadequacies of the data available, the conflicting evidence on tests turned up by different investigators, and the usually unanswerable question of how seriously the test results may be affected one way or the other by the testee's background and previous training. "Perhaps some day," writes Super, "the dream of a comprehensive battery of tests and of test weights for all the major occupational fields . . . will be realized, but current opinion is in agreement that both people and occupations are too complex for this to be at all likely." Meantime the counselor has to rely on tenuous inferences based on test data that he cannot trust and that he seldom or never gets a chance to check against the subsequent performance of his clients. "The use of tests by a vocational counselor," Super says, "is therefore of necessity generally not a predictive process but rather a clinical procedure." In the hands of an expert the clinical diagnosis of vocational problems is probably no less accurate than was the diagnosis of disease a few years back. By the same token it is getting so that it takes almost as long to train a really competent vocational counselor as it does to train a physician.

Assessment of Men, by the OSS Assessment Staff, reports on probably the most elaborate application of the clinical procedure that has ever been made, at least in this country. Candidates for assignment to posts under the Office of Strategic Services were sent in groups of 18 to a secluded country estate where they were observed intensively for three and a half days by a corps of psychologists, psychiatrists and sociologists. They were given tests of every description, from those of the ordinary pencil-and-paper variety to those that attempt to duplicate real-life situations calling for self-control, initiative, practical judgment and the ability to cooperate with others. At the close of the session the experts arrived at a total evaluation of each candidate based on all aspects of his behavior during the period of observation. These evaluations, which depended exclusively on the subjective judgments of the staff, were used to determine what if any assignments the candidate was equipped to perform. The whole account is a fascinating example of the ingenuity and insight that psychologists can bring to a problem of personnel selection where the job requirements and the tests most likely to predict them can be only a matter of surmise.

The book called *Educational Meas-*

urement, sponsored and published by the American Council on Education under a subvention from the Grant Foundation, is in many respects the most important book on one branch of testing that has appeared in a long time. Edited by E. F. Lindquist, it represents the work of some 70 collaborators, all of them experts, and most of them contributors to the technical advances made during World War II.

The fact that the book deals specifically with testing as applied to education is of some significance. In no other area of human activity has psychological measurement played a more decisive role than in education. I.Q. and other tests have long been used as a basis for determining the readiness of youngsters to enter the first grade; scholastic aptitude tests have been widely used to select students for college; vocational and interest tests have been used by guidance departments to help pupils make intelligent career choices; and achievement tests are used almost everywhere to estimate the student's level of accomplishment and to evaluate the effectiveness of schools in attaining their educational objectives. The authors of *Educational Measurement* discuss all phases of the subject, but their primary concern is with the theory and practice of achievement testing. The significance of the book derives from this emphasis, for it brings together a vast quantity of material that until now has been only in the minds of the testers or scattered through technical journals. Thus it gives for the first time an integrated account of all the issues involved and cogent suggestions for meeting them. A few differences of opinion crop up among the authors, but these are of the kind one expects in a young and developing field.

The first section of the book shows how measurement can be used to help along the entire educational process, and it leaves no doubt that the possibilities outrun the actualities. Just as the efficient use of tests in industry depends on a thoroughgoing analysis of the jobs to be done, so the development of good tests for use in education depends on analysis of the educational goals that pupils are expected to attain. The trouble is that these goals have rarely been put in a form that specifically describes the kinds of behavior that pupils are expected to exhibit as a result of their education. Without this information the achievement-test maker is somewhat at a loss to know what tasks to include in his test so that it will show how far the pupils have come toward meeting the kinds of demands that will be made of them as adults.

The second section of the book deals with all aspects of the construction of achievement tests, and although the emphasis is on how to design objective tests of the true-false and multiple-choice variety, the reader is reminded that such tests cannot get at many of the variables in human behavior which, being the most complex, are often the most important. The writers deplore the tendency to overwork tests that put a premium on purely verbal or rote learning, and they show that through imaginative test construction much can be done to overcome this tendency. In his chapter "Preliminary Considerations in Objective Test Construction," Lindquist writes: "Many of the more important objectives of the whole program of general education have thus far received little or none of the attention of measurement workers. This fact is closely related to the extremely heavy reliance that has been placed upon pencil-and-paper techniques of measurement in education." This chapter is a rousing challenge to testers and educators alike to break away from their preoccupation with factual knowledge and to concentrate on those aspects of pupil behavior which are more likely to have an enduring value for society. It deserves a wide reading.

The last section of the book contains the most complete discussion of measurement theory as applied to the observation of human behavior that has appeared anywhere. It examines the fundamental assumptions that are implicit in the measurement process and takes a long step in the direction of establishing sound connections between the underlying logic of the human events with which testers deal and the statistical techniques for summarizing them. Irving D. Lorge, in his chapter "The Fundamental Nature of Measurement," regrets that "the conventions of test construction all too frequently confuse the understanding of social and psychological properties and traits by attempting to make the field conform to the standards of mathematics." The chapters following this statement do much to clear up the confusion.

The concern for better achievement testing in the schools has a direct bearing on the problem of identifying the talents of those who have come through the schools. As Thorndike points out in *Personnel Selection*, "The relevance of academic grades to ultimate success in any job is a . . . serious question. Even in such professions as those of law, medicine, and engineering, it must be recognized that performance during training, and grades as an index of that performance, are only partial cues to eventual success in that job." There are two principal reasons why an academic grade may not reflect true competence for the work ahead: it is not usually based on adequate observation of the student's performance while in school, and even when it is, the kinds of performance required in school too frequently bear only a dubious relation to the kinds of things the student is expected to do later on. Soundly designed achievement tests would not only serve to reveal the gaps, but also would help to close them.

From the foregoing it should be apparent that psychological measurement tries, in one way or another, to perform three principal functions: to select the people most likely to succeed in a particular job; to classify people according to the jobs in which they are most likely to succeed; and to determine how well people are actually succeeding in the jobs they have. The word "job" in this context must be taken in a broad sense to include not only such activities as practicing medicine or driving a truck, but also taking a course in history or getting along with one's neighbors. A test is a sample of any observable behavior obtained by giving an individual certain specified tasks to do. The tasks one finds in psychological tests cover an enormous range: they may require the subject to give the meanings of certain words, to tell what he sees in a blob of colored ink, to operate a complicated piece of apparatus, or to do any one of a thousand things that the tester thinks may elicit a bit of behavior that will differentiate the subject from his fellows in an important way.

When a test is given for the purpose of selection or classification, it is hoped that the sample of behavior called forth will be predictive of the behavior the individual will exhibit later in doing the job. When a test is given to determine how well a person is doing his present job, it is hoped that the sample of behavior obtained is a fair estimate of his total behavior on the job. If it can be shown empirically that the test contributes significantly to the fulfillment of these hopes, it is said to be valid for the purpose the tester has in mind; if it makes no such contribution, it is said to be invalid.

Thus the validity of a test is its most important property, and the principal, if not the only, concern of research in psychological measurement is to find ways of improving test validity. This can be done to some extent by tinkering with the tests themselves, but in the last analysis the construction of a highly valid test depends on the existence of a sound criterion of job success with which to compare it. Establishing such a criterion is absolutely crucial. Thorndike calls it "the most fundamental and most difficult problem in any selection research program." The writers in *Educational Measurement* give anxious and extended consideration to this problem.

As one might suppose, it is easier to devise reasonably valid tests for routine jobs than for those of a more complex nature. The reason for the difference is not so much in the tests as in obtaining good criteria with which to compare them: one knows fairly well what activities to look for in a successful typist; one is not so certain when it comes to successful schoolteachers or doctors or physicists. Tests are now available that do fairly well in predicting the grades of students in engineering schools, but predicting engineering grades is not the same thing as predicting who will be a good engineer.

The majority of testers seem to agree that there are two main tasks ahead. One is to secure adequate criteria for high-level jobs, and the other is to discover dependable methods of measuring such personal qualities as persistence, initiative and emotional control. After reviewing all the more promising devices for appraising these qualities, Cronbach concludes: "There is at present no method of firmly established validity capable of measuring or describing personality. It is probable that situational tests and projective tests will be made valid and practical, but research must demonstrate where they are valid and where they err." Nevertheless, his final remarks reflect the perennial though careful optimism of most true testers. He says, "Methods are now available which, if used carefully by responsible testers, can unearth the talents in the population and can identify personality aberrations which would cause those talents to be wasted. Building on these techniques, we are in a position to capitalize as never before on the richness of human resources."

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HANDBOOK OF EXPERIMENTAL PSYCHOLOGY, edited by Stanley S. Stevens. John Wiley & Sons, Inc. ($15.00). The unborn human infant is capable of simple learning. Viciousness and docility in rats are inherited. Sea anemones and worms can learn, but there is doubt that the starfish can do so. Certain kinds of male fish are sexually attracted to females whose abdomens are swollen but reject flat-bellied ones. Geese, incubated and reared by a man, followed him as if he were a mother and rejected other geese. Sensitivity to tones of high pitch decreases with age. In machine operation, the efficiency of performance can be increased if control knobs have shapes distinguishable by touch or feel. These items form a small and unrepresentative sampling of the kinds of information presented in this highly technical volume. They indicate something of the nature of experimental psychology, which includes almost any feature of human and animal behavior that can be studied by means of careful observation and experimental technique. Some of the material is interesting, some is dull, some seems picayune, and much of it is too difficult for the general reader. But it indicates that psychologists can be rigorous and quantitative in approaching the problems of their field and that by no means all of them are prone to make sweeping generalizations about glamorous problems on the basis of sketchy information.

THE POPULATION OF INDIA AND PAKISTAN, by Kingsley Davis. Princeton University Press ($7.50). An interpretation of Indian population data undertaken mainly while the author was on the staff of Princeton University's Office of Population Research. This work has the earmarks of a first-class achievement of scholarship and statistical interpretation. Numerous charts, maps and tables.

DISEASES IN OLD AGE, by Robert T. Monroe, M.D., Harvard University Press ($5.00). A "clinical, pathologic, and therapeutic survey" of the records of all the patients (7,941 individuals) over 61 years of age on the medical services of the Peter Bent Brigham Hospital in Boston for the 30-year period from 1913 to 1943. A substantial contribution, even though limited to the experience of a single hospital, to the statistical side of the fledgling discipline of geriatrics.

RADIO, TELEVISION AND SOCIETY, by Charles A. Siepmann. Oxford University Press ($4.75). An interesting account of the development of radio broadcasting, the control of the radio industry by the Federal Communications Commission, of listener characteristics in the U. S. and of British and Canadian broadcasting systems is followed by a discussion of the impact of radio (and of television) on society. In dealing with the social implications of radio, the author concerns himself chiefly with issues such as freedom of speech, education and radio, and the justification of program content by the criterion of number of listeners. He is highly and justly critical of a number of the policies of the radio industry but recognizes and points out the many difficulties encountered by this complex industry. A stimulating and informative book, marred by occasional sermonizing.

CIVIL DEFENSE IN MODERN WAR, by Augustin M. Prentiss. McGraw-Hill Book Company, Inc. ($6.00). An analysis of the damage airpower can do, of the destructive possibilities of atomic, bacteriological and chemical weapons, of the defensive measures that can be taken against these dangers. A large, careful, technical, useful and depressing study.

PRINCIPLES OF HUMAN GEOGRAPHY, by Ellsworth Huntington. John Wiley & Sons, Inc. ($6.25). The sixth edition of a noted text (whose aim, announced in the preface to the first edition, "is to set forth the great principles of geography in its human aspects"), substantially revised to include additional chapters, fresh descriptive material, annotations of recent books and new illustrations.

THE AMATEUR ASTRONOMER

Conducted by Albert G. Ingalls

HOW can a sundial be wrong unless the sun itself is wrong? The well-meaning sundial salesman who offered this logic did not know that the sun keeps correct time at only two instants in the year. The cause of this error, which at one season is as much as 16 minutes, is explained without mathematics in such elementary astronomy textbooks as that of John Charles Duncan, that of William T. Skilling and Robert S. Richardson, and in *Sundials*, by Margaret L. and R. Newton Mayall. It takes only an hour to dig out the information; with the understanding thus acquired of time and the calendar you can have the fun of building a dial that is accurate within a single minute on every day of the year. Such a dial will be unique for the builder's own latitude and longitude; theoretically a dial built by someone next door will differ from it a little.

From an illustration of a dial designed and built by Russell Porter and described in this department, Ronald F. Scott, Box 34, Johnson City, Tenn., made a similar dial with minor improvements. "A really good sundial had been the object of my search for years," he writes. "I tried several built on flat plates but they had many shortcomings. Porter's sundial, with its analemma curve and lens for focusing the sun's image, masters practically all the difficulties with remarkable simplicity. I have been gratified to find that this dial is accurate. The readings vary by no more than one minute from correct time, and often the two match."

Roger Hayward's drawing on the opposite page was made from Scott's data and from familiarity with the prototype in Porter's garden. The tiny lens, only a quarter of an inch in diameter and equal in focal length to the radius of the analemma plate, is mounted in a 12-liter boiling flask obtained from the Corning Glass Works, Corning, N. Y. The curve of the "equation of time" or error of the sun (actually it is the earth that errs) is inscribed on a metal sheet inside the flask; it is the mirror image of the one that appears on a globe. To find the time, the flask is grasped by the neck and rotated on the stud in the lower right-hand part of the illustration and on the two supporting pads until the sun's image bisects the curve. This image then gives the date; the time is read on the scale surrounding the flask.

"The polar-axis stud is tapered," Scott writes, "to fit a tapered hole in the glass, and sits in an adjustable thrust-bearing. The two pads that constitute the north bearing are adjustable vertically, and final adjustment of the sundial is achieved with them. A second hole must be drilled in the flask for the post that holds the plate in position. I spent considerable time trying to figure out how to locate the plate correctly before I struck the happy thought of suspending a plumb bob through the stud hole so that the string represented the axis of rotation. Sighting through the center of the lens enabled me to align the longitudinal axis of the plate quickly, and the transverse axis was positioned by using a level line of sight through the lens. I marked a cross on the flask at the end of the axis opposite the stud hole to show the pointing of the bob in checking the inclination of the axis during adjustment. A lead weight was later mounted inside the flask behind the analemma plate to balance the weight of the neck, as the flask tended to creep in some positions."

Scott's improvement on the prototype is in waterproofing the dial by using copper instead of paper for the time band. Porter warned that extreme care must be taken to locate the stud hole accurately. The holes may be made with a hand drill, an inch of tubing and wet abrasive grains. Scott's tapered hole insures against looseness.

IN spite of a widespread impression, it is not easy to know the inventor and the date of invention of such things as the steamboat, the telegraph and the incandescent lamp. The same applies to the reflecting telescope. He who turns to history to find the solid ground of fact will soon find himself bogged in ooze. Was the inventor of the reflecting telescope the English astronomer John Hadley, who in 1723 made the first good modern reflector with a paraboloidal mirror? Or was it Sir Isaac Newton, who in 1668 built the first reflector with an eyepiece, though he knew no way to parabolize his spherical mirrors? Was it the Scottish mathematician James Gregory, who five years earlier proposed the type of reflector known today as the Gregorian, though for lack of manual dexterity he did not build one? Was it the French mathematician Marin Mersenne, often called Mersennus, who proposed the idea of a reflecting telescope to the French philosopher René Descartes in 1639, only to be told that it was fallacious? Was it the English mathematician Leonard Digges, who used concave mirrors before 1571, though probably without an eyepiece and as terrestrial telescopes? Was it the English philosopher Roger Bacon, who with Peter Peregrinus spent three years and the equivalent of $3,000 learning to make concave mirrors in approximately 1267? That Bacon even then understood spherical aberration is shown by his statement that the focal length is much less for rays from the outer zones of the mirror, and that it is half the radius of curvature. He left no record of the uses of the two mirrors that he made, but L. W. Taylor of Oberlin University tells us that a century later Peter of Trau recorded the tradition that with Bacon's mirrors "you could see what people were doing in any part of the world." He adds that the students at Oxford University spent so much time experimenting with these mirrors that the University authorities had them smashed. Perhaps their "experiments" were not limited to pure science.

It is thus that the invention of the reflecting telescope is blurred. Like most inventions it was a gradual process. The English mathematician Robert Smith, in his *Compleat System of Opticks*, published in 1738, refers to Gregory as "the first inventor" of the reflecting telescope; but Sir John Pringle in his *Discourse on the Invention and Improvement of the Reflecting Telescope*, delivered in 1777 before the Royal Society of London, designated Newton as "the main and effectual inventor." Pringle looked down his nose at the telescope which the French sculptor Guillaume Cassegrain revealed in 1672, describing it as merely "a disguised Gregorian never put into execution by its author"; but Louis Bell has pointed out in *Popular Astronomy* that "it is the irony of time that Cassegrain's form is the one that has survived in the great telescopes."

It may be surprising that Mersenne, Digges and others did not build directly upon the advances of their predecessors. Because of the lack of facilities for disseminating such information, they no doubt remained unaware of those advances. Galileo, who lived from 1564 to 1642 and built the first astronomical telescope, did not know that Leonardo da

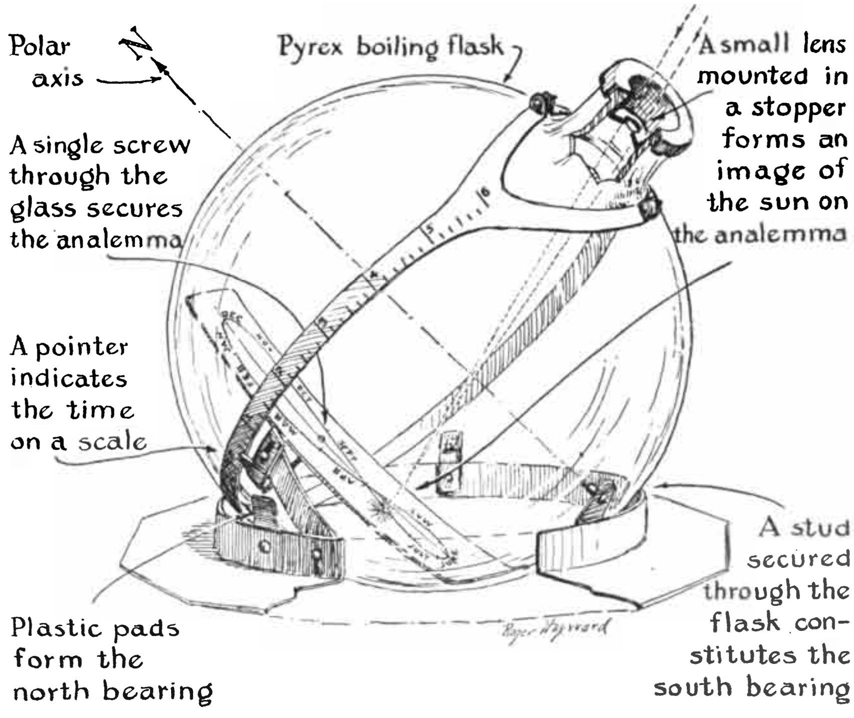
Vinci, who lived in Italy a century earlier, had designed machines for grinding concave mirrors; none of Leonardo's scientific writings were published until 1880, and they have not all been published yet.

In 1885, two centuries after Cassegrain's invention, a modification of the optics of that telescope was proposed in *English Mechanics* by an unknown contributor with the initials A.S.L. He proposed to substitute a simple sphere for the hyperboloidal secondary and to shape the paraboloidal primary so as to balance the aberrations of the secondary. This would call for an ellipsoid, sometimes loosely called an "undercorrected paraboloid." So far as is known nothing tangible resulted from the proposal of A.S.L.

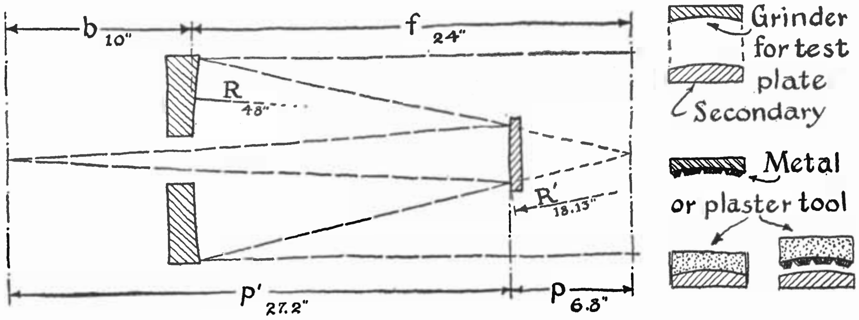
In 1931 the American amateur telescope maker Daniel E. McGuire of Shadyside, Ohio, independently proposed the same escape from the fussy difficulties connected with shaping the small hyperboloidal secondary. Early in the same year, unknown to McGuire, H. E. Dall of England had made such a telescope; it is shown on page 447 of *Amateur Telescope Making*. However, Dall did not reveal the method for calculating the curvature of the primary. Alan R. Kirkham of Tacoma, Wash., revealed the method in this department in June, 1938, although he did not actually make the telescope. Because these two were the first who were known to have done serious work on it, this department then suggested the name Dall-Kirkham for the spherical-secondary compound telescope.

Since that time a modest number of Dall-Kirkhams have been built and have proved satisfactory. No claim was ever made that they are optically superior to the Cassegrainian. They are simply easier to make, and this is why the armed forces have recently had a number of them made at the Tinsley Laboratories and at the Frankford Arsenal. The older, more difficult Cassegrainian paraboloid-hyperboloid combination still survives, partly from the momentum of tradition, and perhaps because it has been difficult to collect the fragmentary instructions for making the Dall-Kirkham, scattered as they are in several back numbers of SCIENTIFIC AMERICAN. Robert Turner Smith of 735 Cerrito St., Albany, Calif., an employee of the Tinsley Laboratories, has now prepared instructions that are complete in themselves. He writes:

THE compound telescope has an appeal which cannot be denied. The Cassegrainian in particular has advantages both in construction and in observation. Its long equivalent focal length is conveniently folded into a tube only about one fourth as long as that of the Newtonian, an arrangement which results in great stability, less vibration and little overhang of mass beyond the bearings of the mounting. The eyepiece is at the lower end of the tube, more easily accessible and with less sweep than the eyepiece of a Newtonian. In the common focal ratios the Cassegrainian has one-



A sundial and calendar built with a large flask



Position of Secondary

$$p = \frac{f+b}{A+1} = \frac{24''+10''}{4+1} = 6.8''$$

where A = Amplifying power.

Radius of Curvature of Secondary

$$R' = \frac{2p'p}{p'-p} = \frac{2 \times 27.2'' \times 6.8''}{27.2''-6.8''} = 18.13''$$

Percentage of Undercorrection

$$N = 1 - \frac{4p^2}{RR'}\left(\frac{p'+p}{p'}\right)^2$$

$$= 1 - \left(\frac{4 \times 6.8'' \times 6.8''}{48'' \times 18.13''}\right) \times \left(\frac{27.2''+6.8''}{27.2''}\right)^2$$

$$= 1 - (.21254 \times 1.5625)$$

$$= .668 \text{ or } 66.8 \text{ percent}$$

Rule and example for planning the Dall-Kirkham telescope

half the length but twice the power of the usual Newtonian. When high power is desired, a lower-powered eyepiece with greater eye relief can be used to obtain the same power where a short-focus eyepiece with uncomfortably close eye relief would be needed with a Newtonian. When good seeing prevails, the maximum useful power of 50 times the aperture in inches can be attained without resorting to an ultra-short-focus eyepiece.

Despite its advantages the true Cassegrainian presents many problems in the polishing and figuring of its mirrors. The primary, although usually an $f/4$ requiring a "strong" paraboloid, is not too much more difficult to figure than an $f/8$ mirror. On the other hand, the convex hyperboloidal secondary is difficult not only to figure but also to test. The high center and turned-up edge is the opposite of what usually "just happens," and the small linear diameter of the secondary for a moderate-sized primary merely adds to the figuring problem. The test of the secondary requires either a flat of the same diameter as the primary or a short-focus sphere of equal diameter for the Hindle test. All this adds up to a project that few amateurs are willing to embark upon. For those whose determination transcends the difficulties, disappointment usually follows when the perfection of figure of the primary is not equaled in the secondary, for a Cassegrainian is never any better than the figure of its secondary. As a result, the Cassegrainian is maligned and has become something to be avoided.

Several years ago Kirkham and Dall investigated the possibility of leaving the secondary spherical and adjusting the correction of the primary to compensate. Since leaving the secondary spherical amounted to overcorrection, it followed that the primary would have to be undercorrected, which is an easier job than full correction. Parabolizing corrects longitudinal spherical aberration. If the secondary is left spherical it introduces a calculable amount of longitudinal spherical aberration into the system. This spherical aberration is negative, and the secondary would be said to be spherically overcorrected. The primary must therefore contain positive spherical aberration in an equal amount and be spherically undercorrected. All that remains is to determine the exact amount of undercorrection necessary.

The formulas for determining the longitudinal spherical aberration and the percentage of undercorrection are not complex, but they do contain sign conventions which must be strictly adhered to, and are therefore subject to error. They can be simplified into the single formula shown at right center in the drawing [*above*]. In this all quantities are considered to be positive and no sign convention errors are likely. N is the fraction of r^2/R for any zone, R is the radius of curvature of the primary, R' is the radius of curvature of the secondary, and p and p' are the conjugate focal distances of the secondary, as shown in the upper part of the drawing.

To clarify the percentage calculation let us take as an example a 6-inch spherical-secondary Cassegrainian in which the primary has a focus of 24 inches, an amplifying ratio of 4, with the focus falling 10 inches behind the surface of the primary. The radius of curvature of the primary is 48 inches and, from the compound telescope formulas on page 216 of *Amateur Telescope Making*, the radius of curvature of the secondary is 18.13 inches, p is 6.8 inches and p' is 27.2 inches. Substituting these figures in the formulas we have the example worked out there.

Now that we are armed with the information on the percentage of correction necessary in the primary, the question arises: How do we produce a good convex sphere? The problem is relatively simple compared with the hyperbolic secondary of the conventional Cassegrainian, both in figuring and testing. The best means of testing a convex sphere is with a concave spherical master, or test plate. When only one convex surface is to be produced the test plate should be one that is quick and easy to make. The glass grinder on which the secondary mirror has been ground need be given only a quick shine, and a suitable test is at hand. Being concave, it can be tested directly by knife-edge and checked for radius with a steel tape. It need only be polished front and back sufficiently to be seen through for the interference tests. In fact, the shorter the polishing period on the concave sphere, the more likely that the curve will remain truly spherical, provided it received a good grind.

Since the grinder has been used for the test plate it will not be available for making the polisher. The best substitute is a concave metal tool, which can be turned to shape in the lathe [*Amateur Telescope Making—Advanced*, page 55]. A truly spherical and smooth surface is not necessary, since the surface will be covered with pitch in making the polisher. As an alternative a polisher back can be made by greasing the face of the fine-ground secondary mirror, circling it with gummed paper tape and filling this with plaster or dental stone. After the polisher is made and the pitch formed with the mirror, a few minutes of polishing will produce a shine sufficient to obtain the first interference test. This test may show several fringes of difference between the mirror and the test plate. If the fringes are circular and uniformly spaced, then the surfaces are spherical and differ only in radius of curvature, and polishing can be continued. If more than six to ten fringes are apparent, fine grinding was not controlled closely enough to bring the two surfaces coincident and it had best be redone; otherwise prolonged polishing will be necessary to correct the difference.

The final figure of the secondary should be within one-eighth wavelength of truly spherical [*Amateur Telescope Making*, page 261], but this does not require the same appearance under test as two flats that differ by one-eighth wavelength. In making a flat accurate to one-eighth wavelength there is one and only one surface which is flat, or plano, and until this particular surface is arrived at the flat is not accurate to the tolerance specified. In producing curved surfaces accurate to the same standard there is much greater leeway, since the radius of curvature is not critical and may vary by many wavelengths so long as the spherical surface of the final radius does not deviate from truly spherical by more than one-eighth wavelength. This allows a multiple choice of radii, whereas the flat allows a single choice. Therefore, the spherical surface under test may show as many as four or five fringes and still be classed as accurate to one-eighth wavelength, if no fringe is distorted from symmetrical form more than one fourth of a fringe. (One fringe equals one-half wavelength, one half fringe equals one-fourth wavelength, one fourth fringe equals one-eighth wavelength.)

Testing should be done only after both pieces are thoroughly clean and dusted free of particles which could scratch the surface or hold the pieces apart to cause extra fringes. In the final interference test the test plate should be gently rocked on the mirror so that the center of the fringe pattern moves to all zones of the mirror. In all positions of the circular fringe pattern the fringes should show the same circular form and spacing. Any deviation of one half a fringe is readily apparent if there are fewer than six circular fringes in the diameter of the mirror, but detecting a quarter-wave difference becomes difficult and impossible as the number of fringes increases. The fewer the fringes the more accurately the deviations can be estimated.

In order to observe the fringe pattern easily a moderately monochromatic light source is needed. Fringes appear quite clearly under a fluorescent light, and they stand out even more sharply under a sodium or mercury-vapor light. The light should be diffused, and the lamp is best fitted under the top of a black box with the front open so that the angle of the eye is kept small.

All that remains is the figuring of the convex secondary to a spherical surface. The same techniques are used for correcting convex surfaces as for concaves. Low centers or long over-all radius (concave to the test plate) calls for short strokes or inverted rose laps. High centers or short over-all radius (convex to the test plate) calls for long strokes or straight rose laps. During the polishing-out period appropriate steps can be taken to keep the number of fringes small, and it is quite possible to have a good spherical surface at the same time it is polished out. The secondary need never be tested in conjunction with the primary with which it is going to be used, and large flats or spheres are unnecessary. The primary should be figured and tested to the same degree of accuracy as if it were fully corrected. The allowable error in the accuracy of parabolizing should be adhered to, so that the primary will also meet the one-eighth wavelength criterion.

In calculating the zonal readings for the undercorrected primary it is best to solve r^2/R for the various zones to be tested, subtract to obtain the difference between zones, and *then* apply the percentage figure, obtained from the formula, to each zonal difference amount. For example, let us say that we will test three zones on the six-inch primary for which we determined the percentage correction to be 66.8 per cent, rounded off to 67 per cent. (Three zones will suffice for our example, but more might be desirable for better control of the figure.) We will take zones .75-inch r, 1.75-inch r and 2.75-inch r. For these zones r^2/R will be .012-inch, .064-inch and .158-inch. Subtracting, we get .052-inch for the difference between zones 1 and 2, and .094-inch for the difference between zones 2 and 3. Taking 67 per cent of these figures, we get .035-inch and .063-inch, and these new differences are those to which the mirror is figured. When the zonal test of the mirror shows that it agrees within the greatest allowable deviation from a perfect figure, in this case 5.5 per cent [see "Accuracy in Parabolizing," Table I, *Amateur Telescope Making*, page 257], the mirror will be undercorrected by the proper amount, and it will perform as well with its secondary as a fully corrected primary will with a hyperboloidal secondary.

A complicated ray trace of the spherical secondary would undoubtedly show some higher-order differences of correction when compared with the hyperboloidal secondary system. Coma is probably increased slightly, but for all practical purposes it can be considered negligible. Moreover, most of us are not concerned with higher-order coma or the like. We want a convenient, high-powered telescope that doesn't take 10 years of experience to build. We want to split that double star the book says this diameter should split; we want to find the Great Wall on the Moon, Syrtis Major on Mars, Cassini's division in Saturn's ring, see a transit of a satellite of Jupiter, locate Mercury in the twilight, pick out the Ring Nebula by knowing where to point in Lyra, and accomplish it all with a pair of mirrors that were fun to make in the first place. If, after our apprenticeship on the standard beginner's six-inch Newtonian, we are going to build only one telescope and then see the sights, we might as well make the one that has the highest power and is easiest to use. Even if we just like to make telescopes, the spherical-secondary Cassegrainian is an intriguing one to add to the list. It works fine. I know because I've got one.

Editor's note: George P. Arnold has shown by ray tracing that the equation for N is correct to less than one per cent of N for an eight-inch $f/12$ system with an $f/3$ primary, and again for a ten-inch $f/19$ system with an $f/5$ primary.

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