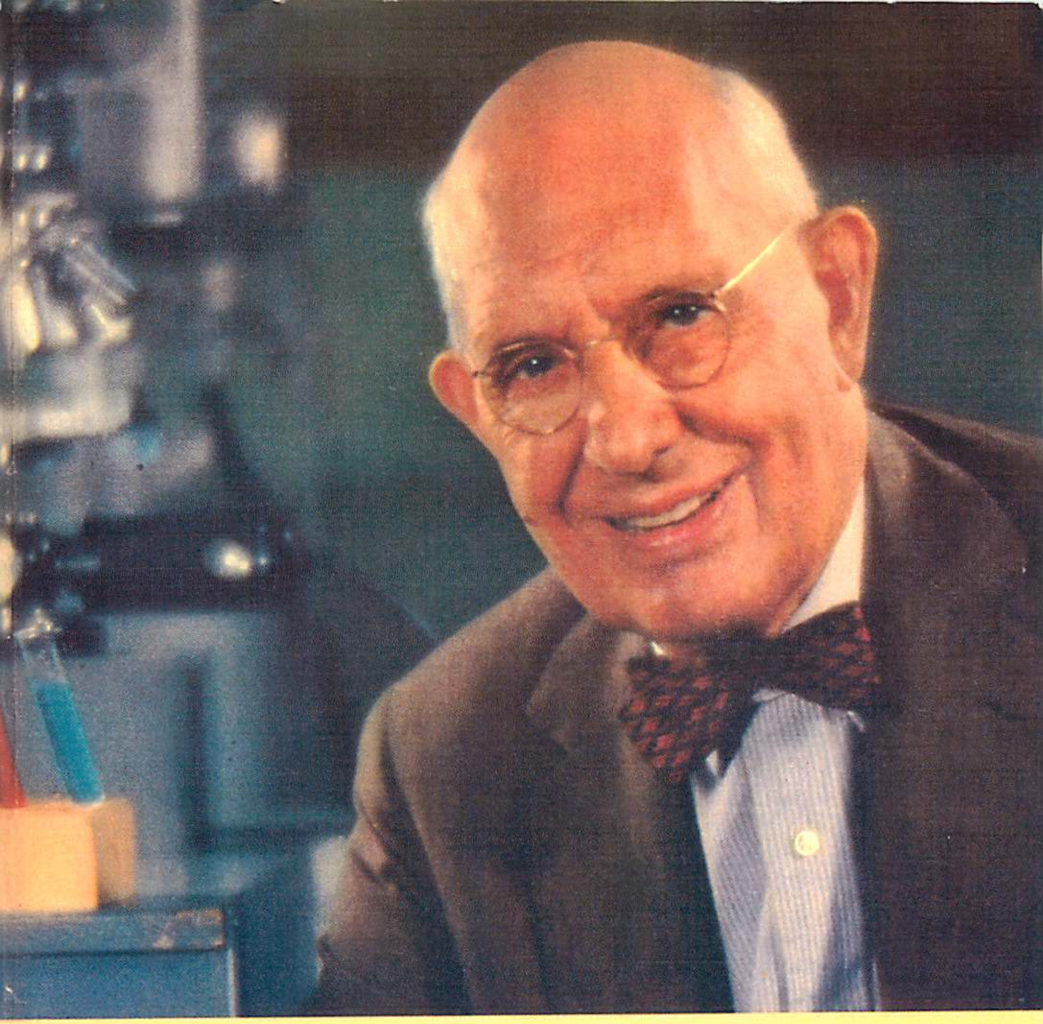


Kettering Digest

"It is man's destiny to ponder on the riddle of existence, and as a by-product of his wonderment, to create a new life on this earth."

—Charles Franklin Kettering

A collection of articles commemorating Charles F. Kettering's 80th birthday

GET OFF ROUTE 25, YOUNG MAN

Half a world of opportunity lies on either side of the best traveled highway, Mr. Kettering points out in the following article. Consequently, we should not fear leaving the main path and venturing into unknown fields. "Get Off Route 25, Young Man" has been selected to keynote this collection of articles about Mr. Kettering because it typifies the many challenges which he has hurled at complacency during his productive career.

By Charles F. Kettering
Condensed from Collier's

THERE ARE WAYS in which we can read and definitely forecast the future so far as many material things are concerned. As you already know, there are just two kinds of knowledge in the world: knowledge about people, and knowledge about things.

Knowledge about things is generally quite stable. Knowledge about people is quite unstable and unpredictable. No one can draw future conclusions from the way people react today. But the future in many material things can be projected.

We can tell pretty well what kind of electric lights you are going to have 15 or 20 years in the future, provided no radically new information comes into the picture. We know about what kind of automobiles you are going to have, what kind of Diesel engine, what kind of gas turbine. We know a lot of things because we know the factors that can enter into those things and change them.

We make advances into new knowledge by three methods: inventions, discoveries and research. The methods are quite different. The inventor sees the need for something and tries to do it. It doesn't make any difference whether anybody else around him sees it or not.

Columbus was a great *inventor* because he believed the earth was round and if he sailed west he'd come to the East Indies. He found the West Indies, instead, which later showed that the world was a lot bigger than he thought it was. What is important is that up until that time it was assumed the earth was flat and you fell off the edges if you got too close.

Everyone was against poor Columbus when he started, even his own sailors. And that pattern is important, too. New inventions—not discoveries, not research — are made always under the stress of an attitude that it cannot be done.

We talk about Thomas A. Edison's invention of the electric light. The electric light is simply the symbol of the whole electric system that made possible the distribution of electric current so that the world could have good artificial light. Edison saw that picture in its entirety, and he started to work out the individual pieces. Some pieces came easy; others came harder. The filament of the incandescent lamp was a very difficult thing to achieve. But it has been followed by intense research ever since its discovery. Progress is still being made, and there will be more progress.

Fundamentally, if we oversimplify, we can say the electric light is nothing but a wire in a bottle. As simple as that sounds, the number of factors involved is tremendous. The difficulties that Edison had in getting a filament in an incandescent lamp had never been told until fairly recently, when we opened his laboratories and from his notes published a booklet on the incandescent lamp. To that extent, all inventions follow the same kind of pattern and there must be a few strong, stout hearts that will go along financially during that period of development; otherwise, there will be no progress.

The inventor is doing a thing for the first time. In that respect his work isn't very good; it is the work of an amateur, because an amateur is a fellow who is doing a thing for the first time.

Inventors and researchers are exactly alike in this one respect, because a researcher works on something for the first time and the answer he finds is seldom the final one. Generally, people expect too much of a new invention or of research development, because the first attempts are soon discarded and go to the museum. Go look at them and see where our great industries started from. The products just barely worked.

My home is in Dayton, Ohio, and I was a friend of the Wright family and learned to fly on the very early Wright airplanes. Their first flight was on the 17th of December, 53 years ago. Everyone was perfectly sure that it was a crazy thing to try.

The undertakers moved into Kitty Hawk with a number of caskets because they thought the Wrights would kill themselves.

When they made those first three flights on December 17, 1903, they wired their sister that they had succeeded, that they were very happy, and that they should be home for Christmas.

She thought it was a world-shaking event, so she very excitedly called a Dayton newspaper on the telephone. She rang and rang and rang. The newspaper boys were playing pinochle, but finally one of them answered.

He said, "Yes?"

She said, "This is Katherine Wright speaking," and very excitedly read the telegram.

He said, "Good. Glad to hear the boys are going to get home for Christmas," and hung up the telephone.

The newspaperman said to the others: "Nobody's going to catch me on that, because it has been proved mathematically that a heavier-than-air machine can't fly."

An inventor often has to overcome so-called "proof" or his own work may be perfectly useless.

I had a friend who was the research and development man for one of the British railroads. He came to this country to deliver a commencement address at a technical university. After the address he came to Detroit to see our laboratories.

"Ket," he said, "when you were over in London last year you told me some things you fellows were doing with Diesel locomotives and you lied to me."

I said, "Not intentionally."

"But," he said, "you told me you were running these locomotives about a hundred miles an hour."

I said, "We are."

"And that you were taking power on the front wheels; that is, the wheels that are ahead."

I said, "We are."

He said, "I have the formulas in my portfolio that say you can't do that."

I said, "For Heaven's sake, don't let the locomotive know about it."

I said to him, "I won't argue with you at all." I took the telephone, called Chicago and got him transportation from Chicago to Denver, and flew him to Chicago to make the connection. He made the trip to Denver, where I had him ride part way on the Diesel engines.

He stopped in to see me on his way back. He was returning to England. I said, "I didn't expect to see you again. Did you ride that locomotive?"

"Yes," he said.

"Did it go a hundred miles an hour?"

"It did."

"Well," I said, "that's the reason I didn't expect to see you back. Maybe you forgot to take the portfolio with the equations in it."

He said, "The thing that amazes me is why we could be so one hundred per cent wrong."

I said, "You weren't wrong. You didn't start in right."

The two of us got out his formulas. He wasn't talking about our locomotive at all. Our locomotive uses an ordinary truck like a streetcar's. He was talking about a locomotive with a rigid frame which would normally have a small-wheel lead truck in front of it.

I said, "What's the use of using mathematics on one kind of thing and then applying it to another which is in no way related? It isn't even a second cousin to it."

We sometimes set up these limiting conditions, and they keep us from trying out experiments.

One of the great differences between the inventor and other men is that he is willing to try the thing. In the airplane experiment, the Wright Brothers had first flown kites and had drawn knowledge from them. They finally said, "If we had an engine we could fly," and kept trying and trying until they did fly with an engine they were forced to develop themselves. They didn't care what anybody thought about it; they were pretty sure they could do it because the birds were flying.

As I said before, my home is in Dayton, and we have had our laboratories for years in Detroit, which is several hundred miles away. I keep my home in Ohio and used to drive back and forth week ends.

Some of the people who worked with me also drove between Dayton and Detroit. One said, "I understand you drive from here to Dayton in four and one-half hours."

I said, "I can do that once in a while, depending on traffic."

He said, "I don't believe it."

I said, "But I do it."

He said, "I'm a much better driver than you are, and I can't do it."

I said, "I'm going down Friday. Why don't you ride along with me?"

So we rode into Dayton in about four and one-half hours, or a little more and he said, "Hell, no wonder you can do it. You didn't stay on Route 25!"

Now, Route 25 is the red line that is marked on all the maps between Detroit and Dayton. If you are a stranger, that's the road you should take. It never occurred to my colleague that you could take any other road on either side of Route 25. There's a lot of country on either side of it; in fact, half the earth is on each side of it.

Often the biggest problem the inventor has is not in getting his apparatus to work, but in getting it to work in tune with what the public thinks at the time.

A great many years ago, when the internal combustion engine was first started, gasoline was, as everyone knows, a drug on the market. Kerosene, which you used in lamps (this was before the electric light), was the only thing you refined petroleum for.

As the automobile industry began to grow, gasoline became an important factor. It was back in 1912 when some of us began to think what we might do to improve gasoline-engine efficiency; that is, see how many more miles per gallon we could get out of it.

We soon found out that engine knock had little whatever to do with the engine itself. It was the gasoline that caused it. We discovered that if you make gasoline so it won't knock, you can raise the compression of your engine and get more miles per gallon.

I was vitally interested in this knock business, because I was blamed for it. When I put the self-starter in automobiles along about 1911 or 1912, this necessitated taking the magneto off and putting on battery ignition. Some self-styled experts said that's when I put the knock in motors.

What actually happened was that after we put the self-starter on automobiles, women began to drive them and more people began to buy them. This required more gas, and in the rush to fill the demand, they produced unknowingly a poorer gas which actually knocked more.

After guessing that something could probably be put in gasoline as an additive to stop the knock, we started out on the very long research which finally turned up Ethyl gas. We felt it could be done because we had added some elemental iodine to the fuel and it stopped the knock. The problem there was you couldn't get enough iodine and some of its compounds were quite corrosive.

After 10 to 12 years' research, we finally got tetraethyl lead, which is the base of Ethyl gas. But to our surprise, we found Ethyl gas not only stopped the knocks, it dissolved spark plugs. That was because the lead burned to lead oxide which is a very good flux for dissolving both the porcelain and nickel, of which spark plugs are made.

So, what were we going to do about that? Well, we put in some ordinary carbon tetrachloride — the stuff used in fire extinguishers and for cleaning purposes. That saved the spark plugs, but the lead chloride that formed softened with the heat and stuck on the exhaust valves. Frequently, a chunk would break off and an exhaust valve would be burned out.

Then we had to move up in the chemical table to the next material, which was bromine; and bromine could not be obtained. At the time there were only about 800,000 pounds of bromine made in the world per year, most of it used in photography and in manufacturing a well-known headache remedy. Everybody told us right away we couldn't get enough bromine.

We finally went to the Dow Chemical Company in Midland, Michigan, a firm which produced bromine as a by-product from the brine taken from the salt wells. They agreed to drill a dozen new wells. We also knew there was bromine in the sea. There is *one pound* of bromine for *ten tons* of sea water.

Well, at once out came the slide rules, and some people started to figure how much heat it would take to evaporate ten tons of sea water for one pound of bromine. And they said right away, "You couldn't possibly do that; it would be too expensive."

What *we* did was to evaporate the one pound of bromine out of the ten tons of sea water! That took very little heat.

There we were getting off Route 25 again.

It is important to understand the difficulties of a new project, because when you develop something new and start to use it, you run into sets of problems that you never dreamed existed. Inventors mustn't be too dogmatic. That is, they must not figure things out and stand too firmly by figures, because calculations are no better than what you put into them, and customers may radically change the factors.

Right after the war some Swiss friends of ours who were in the Diesel engine business came over here. They were amazed at the great number of Diesel engines we had built for the Navy.

Finally, one of the boys said to me, "Ket, would you get sore if we ask you a question?"

I said, "No, I wouldn't."

He said, "We'd like to know how you got yourself into such a state of mind that you could design such an unconventional engine as that?"

I said, "We didn't design the engine. We made a single-cylinder engine and gave it a half-dozen types of pistons and let it pick out the one it liked the best. This was done for all other important components. We just ran errands for that single-cylinder engine.

"After we had been helping it try these parts for four or five years, the engine theoretically said, 'You haven't done much for me recently.' We said, 'All right, we'll make you into a 16-cylinder engine and see what you can do for a customer.' "

The Navy was interested in a new submarine engine, so a modification of this engine was built and the Navy ran a thorough test. That's the way we started work on submarines.

To show you how much smarter the engines are than the engineers, when we went into the locomotive business the best that anybody could figure out with the best slide rules was that it would be about 50 or 60 thousand miles before you had to change the piston rings on the engines. Now, the piston that the engine had picked out was quite a little better than that; the rings will run about 500,000 miles, and the pistons have been known to run 1,500,000. That's about 30 times better than the original estimate.

A group of theoretical engineers was looking at our engine one day. One of them remarked. "If I were making an engine, I certainly wouldn't make it that way."

We answered by saying, "That is the way the engine wanted to be."

Recently, a piston that runs 1,500,000 miles and one that runs 50,000 miles were sawed in half and exhibited at an engineering convention. There I met a friend of mine, an engineer. He said, "I wouldn't have that piston. I don't see how you ever designed a thing like that."

I showed him the card and said, "That ran 1,500,000 miles."

He said, "You couldn't *give* me a piston like that." He pointed to the other one and said, "That's the only one that's any good."

I said, "How do you know?"

He said, "I'm an engineer."

I said, "Yes, but were you ever a piston in a Diesel engine?"

Sometimes we so overestimate what we know that we completely stymie the flexibility of the device to do what it can do. Your customers use your product in ways you never expected. The intelligent, flexible use of an idea is what develops great industry.

The thing I'd like to get across is that there are no limits to the undone things. They come along and will come along with the calendar. One way is by invention, one is by discovery (which is usually accidental, of course) and the third is by systematic research. What is ahead of us can be anything you like because we know practically nothing about anything. The only thing we do sometimes is to give Latin and Greek names to these things we don't know so that we can get away with it.

I have spent a great many years on the study of the growth of the plant, because that is the whole story of energy. That is, the plant has the ability to catch some of the energy from the sun and hold it. That is the way we get our vegetables and our living and everything else. Also, it is that ability to catch the solar energy and hold it that made our oil and coal fields.

We haven't the slightest idea how it is done, but we know that we can find out if we will do it the way the *plant* wants to do it instead of the way *we* think it ought to do it.

I am mentioning that because we call it the study of chlorophyll. That sounds all right, but the word "chlorophyll" is the Greek word for "green leaf," and we don't know a bit more about it in Greek than we do in English. You would be amazed at how many things we think we know are only a Latin or Greek synonym. We just spring it on some fellow and he is afraid to question us and lets it pass.

I used to put up some money for the summer symposiums in theoretical physics at one of our great state universities. The physicists there often asked, "Why are you so interested in this advanced course in physics?"

I said, "Because we don't know anything about physics, and anything we learn will help along."

They said, "Why don't you come to us? We know the equations for every phenomenon of nature."

I said, "Can you solve the equations?"

"No," they said, "but what are some of the things you'd like to know?"

I said, "I have always wondered why I could see through a pane of glass. Does the light come through the pane of glass, or is it rebroadcast from molecule to molecule?"

"Well," they said, "that's because it's transparent."

Well, if you open Webster's dictionary it will tell you a thing is transparent if you can see through it.

I said, "When you say you can see through a pane of glass because it is transparent, you are actually saying you can see through a pane of glass because you can see through a pane of glass."

The main thing we inventors are trying to do is to pull apart the elements of a problem and then try to find out whether we know enough about those individual elements to put the whole together. We don't manufacture automobiles; we manufacture pieces which, when put together, make an automobile.

The process of research is to pull the problem apart into its different elements, a great many of which you already know about. When you get it pulled apart, you can work on the things you don't know about. We must get people to understand this procedure.

Edison was the first one of the organized researchers. He found it necessary to pull these things apart into their different elements. In building a house you need shingles, flooring, bricks and furnace; and you haven't a house until you get the pieces all there. Ideas are exactly the same way. Sometimes the invention you make is entirely different from the utility that eventually results.

The Brookings Institute made the

study which said that the more education you had the less likely you were to be an inventor.

I don't know anything about that, but if that is true there must be a reason for it because it ought to be exactly opposite to that.

I think the reason is simply that, from the time you start kindergarten right on through the time you are examined three, four or five times a year, if you flunk it is considered something terrible. But an inventor can fail 999 times, and if he succeeds once he is in. That's the difference between education and invention. The young fellow gets so afraid of the word "failure" that he's afraid to attempt to do anything.

We have taken these young, educated boys, and they turn out to be marvelous inventors after we unloose them. We tell them, "Well, we'll bet you 100 to 1, or 200 to 1, that anything you do will fail. But what you want to do is find out *why* you fail so you will learn to fail intelligently; because the failures are the different steppingstones which lead you to the final answer. Failure is as essential in making inventions as the problem itself, or as practice in learning to play a game."

There is a great deal of argument as to what necessitates an invention. We sometimes say that necessity is the mother of invention. Not necessarily. Necessity was certainly not the mother of the airplane. Nobody wanted to fly, and nobody was clamoring for it. It was mothered by the fact that these Wright boys thought they knew how they could do it.

Thomas A. Edison analyzed his problems and he saw, through the electric light, not only the electric light but the entire electrical industry which has put thousands and thousands of people to work.

These inventions look like frail and unsubstantial things when they start out. It is, however, the opening up of new fields that guarantees you will have employment for everybody and a better standard of living.

Don't let anybody tell you we have reached the end of things at all, because we haven't. We have only reached the end of human progress when we look down instead of up. Our educational systems need to stress the unfinished state of our knowledge about nature and recognize that inventions, discoveries and research are ways of looking up.

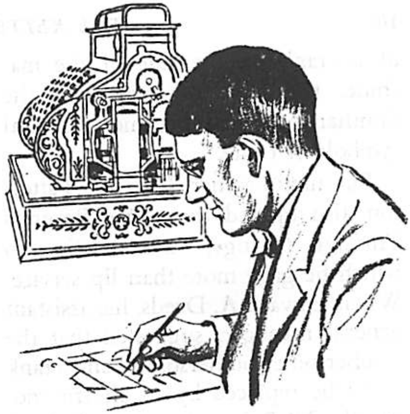
Quick Quotes from C. F. K.

Nothing ever built arose to touch the skies unless some man dreamed that it should, some man believed that it could, and some man willed that it must.

Thinking is the one thing in the world upon which no one has ever been able to put a tax or tariff.

Engineering is a combination of brains and materials. The more brains, the less materials.

They called John H. Patterson's cash register factory "Alice-in-Wonderlandish," where almost anything could — and usually did — happen. Yet it was an invaluable "graduate school" for the lanky ex-farm boy who was to become the greatest industrial scientist of his time.



"Of Course, We Can"

IN 1904 The National Cash Register Company of Dayton, Ohio, qualified for inclusion on anyone's list of unusual businesses. Launched 20 years before by energetic, mustachioed John Henry Patterson, it had grown even beyond the dreams of its perpetually optimistic founder.

Patterson preached and practiced—with evangelistic fervor—the dictum that "The more we sell, the more good we do." It was his conviction that by discouraging "manipulations" the National cash register was one of the greatest forces for good ever devised by man.

All that was needed for the world to share this belief was a dramatic presentation of the facts, he reasoned. It was as simple as that, and toward this goal the wiry tycoon lent his inexhaustible energy for almost 40 years. He also staked both his reputation and his fortune on the conviction that his important message could be sold to a world content with the old-fashioned cash drawer simply through long-standing inertia to change.

To achieve his objectives Patterson resorted to unusual means. He demonstrated that shoddy workmanship was not to be tolerated by smashing to bits, before startled visitors, a register which refused to work. To dramatize the necessity for cutting red tape, he burned all of the bookkeeping volumes in a department whose records were impressive but useless.

If such goings-on were Alice-in-Wonderlandish, as one writer described them, they nevertheless got results. From a crude clock-like gadget designed to keep greedy bartenders from fleecing cafe owners, the cash register by 1904 had evolved into a splendid brass and steel mechanical brain. It served as a stern and unyielding auditor of the nation's retail transactions. The twist of a crank on the side of the machine, the whir of gears and the familiar bell had become universal symbols of trade.

But motto-coiner John H. Patterson also opined that "We Progress Through Change," a conviction to which he gave more than lip service. When Edward A. Deeds, his assistant general manager, suggested that the cumbersome, bothersome hand crank could be replaced by an electric motor, the NCR founder was delighted.

Experts were called in to discuss the problem. They promptly pronounced it insoluble. To power a cash register, they decreed, a motor would have to be as big as the machine itself. It was ridiculous. The clerks of America would simply have to keep cranking away.

Neither Patterson nor Deeds was discouraged. The former had built a world-wide business refuting "expert" opinion and the latter had already constructed a crude motor which indicated that electrification of the register was feasible. Deeds knew, however, that the road to successful electrification would be long and rough. Involved in factory production problems, Deeds wrote to one of his former college professors, then at Ohio State University, about the problem and the man who would be needed to solve it.

The professor replied, "It just happens that this year we have such a man. His name is Charles F. Kettering."

Although subsequent events were to prove the accuracy of that statement, young Kettering wondered at first whether the job was for him even if he were the man for the job. Serving as an electrical engineer in a cash register factory seemed as far fetched at that time as hiring a portrait artist for a house-painting crew.

The challenge of the job was strong, however—perhaps the deciding factor. The pay—$50 a week—was also unusual. Kettering went to Dayton on the first of July, 1904. His five years at NCR were to have important repercussions not only for him and the company, but for businessmen everywhere.

The newcomer to Dayton bore little resemblance to the typical diploma winner. He was then 28 years old, with far more than average experience in batting down obstacles. Neither bouts with near blindness, scarcity of money nor his limited rural background had proved sufficient to offer more than temporary setbacks. The lanky ex-farm boy had not chucked his University diploma into a wastebasket — as legend has it—but he did have a healthy aversion toward the dogmatism to which the academic mind is sometimes prey. Practicality to an astounding degree was an integral part of his make-up. Fortified with his salty experiences on a telephone line gang, he was more than ready to do battle in Patterson's lively money-box factory, or wherever else his unique talents might lead.

He was as little shaken by the dire predictions of the electrical experts as Deeds had been. "Of course we can do it," he told Deeds. "You don't need a big motor. You don't need efficiency. What you want is a spasm of quick turning power. What you want is torque."

Kettering tackled the "impossible" job immediately. During the annual NCR vacation shutdown that August, he and his machinist assistant labored away in the deserted plant. Since the factory power had been shut off, Kettering spent hours turning by hand the lathe on which his hastily designed parts were being machined.

Complications piled up on complications. First it was necessary to design and build a motor of just the right power. Next, this power had to be applied in a way that was completely new. Unlike other electrically driven machines, a cash register operates in complete cycles; its parts must be in a certain position before it is operated, and they must be returned to that position when the operation is completed. To add to Kettering's problems, cash registers even then were sold all over the world. Voltages might range from 110 in Dayton to 220 in Zanzibar. Thus, Kettering's new-type motor had to be universal in design, the most flexible ever created. It had to accept not only varying voltages, but different current cycles, and either alternating or direct current as well.

Kettering and his aides in Inventions Department No. 3 dug into the problems with seeming disregard for their inherent difficulties. Ideas boiled and erupted. Apparatus and partially dismantled registers littered their workbenches. Occasionally, epic arguments alarmed employees in adjoining departments. These "discussions" later prompted Kettering to explain that research was about 10 per cent experiment and 90 per cent getting along with fellow workers. "We fought, but we never stayed sore," he said.

To John H. Patterson, obsessed with neatness and determined to run the world's most spic and span factory, the goings on in Inventions 3 had their distasteful side. He ordered that the windows be replaced with frosted glass. His object was to spare the thousands of visitors to his model factory from having to view this cluttered, seemingly disorderly phase of business machine evolution. With typical shrewdness, however, Patterson did nothing to hamper the progress which was slowly being made in the electrification project.

For the try-and-then-try-again attitude, which had resulted in monumental overtime for everyone connected with the job, was beginning to pay off. Kettering and his tireless crew managed to design and build a truly universal motor. Different voltages, varying cycles, A.C. or D.C. current—all could be used, with minor production changes in the motor. The Kettering motor used relatively few parts. These were so standardized that they would fit within the available space regardless of modifications for different uses. The problem of applying the motor's power to the register was tackled in several ways, finally evolving in a mechanical clutch quite similar to those used even today on the most advanced cash registers.

Just when it appeared that the "impossible" project had been successfully wrapped up, several alarming reports from the company's far-flung salesmen sped into Dayton. Now and then a bartender or storekeeper would step smartly to one of the new registers only to receive a solid jolt of electricity when he touched the keys. The first of the inevitable bugs between experimental and production machines had arisen to plague the men in Inventions 3.

Kettering and his aides immediately plunged into the job of re-examining everything they had done so far. His fellow workers observed that when the obstacles seemed the greatest, Kettering was prone to plod ahead with a determination that was almost superhuman. Against this stubborn streak the bugs had no chance. One by one they were exterminated, and the world's first electric cash register was ready for the mass market in 1906.

How ready the market was for it soon became apparent. In a short time the highly pleased Deeds was able to inform the equally pleased Patterson that the factory was not in a position to take care of additional work. "They are crowded with orders for electrically operated registers and are falling behind at the rate of 50 orders per week," he reported happily.

Kettering immediately got a raise and then a new job. A competitor company had for once caught John H. Patterson's team napping. Its new, low-priced machine was threatening to steal a major portion of the company's hard-won business. NCR salesmen howled that without a comparably priced machine they were sure to lose the lower end of their market. The only way to save the game was to bring out a better machine at even lower cost, and do it faster than had ever been done before.

In this crisis, Patterson and Deeds again looked to Kettering. The measure of their faith in his ability is that they entrusted one of the most important engineering projects in the company's history to a comparative neophyte in the rough cash register business.

But they counted on what William A. Chryst, Kettering's chief designer, had described as Kettering's uncanny understanding of machines: "He'd see the whole thing in his head," Chryst said. "He could write down a complete parts list for it in a jiffy, without thinking. He'd draw the thing out for you, making motions in the air."

In typical fashion, Kettering started the new project with a blank piece of paper. He was completely unhampered by earlier concepts, and in some cases, prejudice, of cash register design. His plan was to operate the new register with springs, which would compress, ready for the next transaction, when the drawer was closed.

Among some of the most powerful executives of the company the cries of protest were long and loud. Everybody knew that springs were undependable. They lost their strength. They broke. You couldn't make a decent register with springs regardless of what an electrical wizard told you. What did he know about springs anyway?

Kettering won the argument, and in a simple way. "What time is it?" he asked one of the most acid critics of springs, who was a watch collector and always carried two or three timepieces on his person. As the executive pulled out his best watch, Kettering snapped, "You don't mean to tell me you try to tell time with that thing?"

"Why, it hasn't lost a minute in years," the astonished executive sputtered.

"Oh? Let's see what makes it go," Kettering said simply. The resulting wave of laughter swept away the last of the objections to springs.

The Kettering-led team rushed ahead with the new register with competition-conscious John H. Patterson prodding them on. Within six weeks, the drawings and specifications had been completed, a record unequalled in the long history of the company, before or since.

Three months later the tool model was completed and John H. Patterson was gazing fondly at the new register's exposed insides.

"Now, now, now," he told Kettering, "this new machine looks as if it is going to be splendid. When do you think we can go into production?"

"I can't be certain, but I suppose it will take about a year," Kettering replied.

The NCR president was obviously displeased. "That will never do. We will double your space and you can put on twice as many people," Patterson countered.

"What good will that do?" Kettering asked.

"Well, indeed!" The storm warnings were going up. "If you have so many men to dig so many rods of ditch, then twice as many men will take only half the time to dig it, won't they?"

"The best way to answer your question, Mr. Patterson, is to ask you one," Kettering said. "If one hen can hatch out a set of eggs in three weeks, can two hens hatch them out in a week and a half?"

Patterson, who could concede a point as well as make one, pressed the subject no further. From then on, the pace of the project was left to Kettering. A year later, the new "Class 1000" register was on the market. With modifications over the years, it remained there — with unparalleled tenacity — for more than 40 years. Countless thousands of the "six-week wonders" are still in use.

Although electrification of the cash register and development of the Class 1000 low-price models represented what today would be called "crash" programs, Kettering's two other major contributions at NCR typified his methodical, progressive approach to engineering. One was the inauguration of what has become today the Class 2000 line of National accounting machines. These multiple-counter mechanical marvels have the ability to subtract as well as add. The principle on which they are based was first introduced by Kettering and expanded by Chryst in a machine designed for certifying bank passbooks. Another Kettering system that has proved a milestone in better department store operation is the O.K. charge phone, which provides quick and accurate authorization of charge purchases.

Less widely known was the impact Kettering's engineering methods had on the company's over-all developmental program. By making thorough engineering studies in advance of machine design, he was able to complete his drawings in such exact measurements that production tools could be started even before an experimental model was completed. This sped up immensely the introduction of new and improved products. The same engineering techniques are still used at NCR.

These and other contributions resulted in a unique tribute to Kettering in 1936 when he was elected to the company's Board of Directors: Said NCR's chief engineer, "Even after 25 years, the influence of Charles F. Kettering's work is present in our product today more than that of any other single man."

Kettering's "graduate work" in John H. Patterson's stern school had clearly benefited the company as much as the pupil, a pattern which was to be reflected throughout the inventor's post-graduate career.

Of Jobs and Men

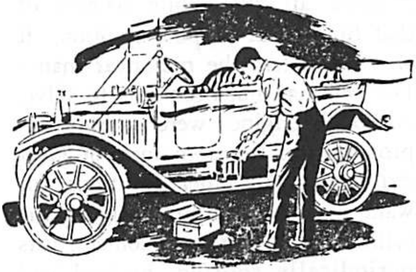
"I have always told my gang that I didn't want any fellow that had a job working for me, but I did want some fellows whom the jobs had. In other words, I want the job to get the fellow and not the fellow to get the job.

"And I want that job to get hold of this fellow so hard that, no matter where he is, the job has got him. The first thing he thinks when he opens his eyes in the morning is the job. There is the job sitting right on the foot of the bed, ready to grab him. And it is sitting there until his eyes close and he passes out of consciousness. But that job is just there all the time, no matter where. The job has got him.

"That is the only kind of fellow you can trust to do a real good piece of work, one whose job has got hold of him so hard that he cannot get away from it. They are not such bad taskmasters, good jobs. So don't be afraid if one gets you. It isn't going to hurt you at all."

—C. F. K.

Revolution on Central Avenue



At the cost of a few thousand dollars and many sleepless nights, a little group of young men demolished the last major barrier to widespread use of the automobile. The fact that the self-starter and the modern ignition system were born in a barn in no way diminished their revolutionary impact on what was to become our greatest industry.

ANYONE strolling up the alley behind 319 Central Avenue in Dayton, Ohio, during the years 1909 and 1910 might have wondered what manner of project was under way inside the barn at the back of the house. The neighbors must have been puzzled too.

Most of the men who visited the barn would arrive in the late afternoon or early evening. You never knew when they would leave. Two or three of them seemed to spend most of their time at the barn and one—a tall, thin, bespectacled man—practically lived there.

From the hayloft of the barn the buzz of voices could be heard occasionally and the whir of machinery almost always. Whatever was taking place had something to do with cars. There would be the lifting of a hood, the adjustment of wires and then a car would roar down the alley, often as not with the lanky fellow wearing glasses at the wheel. When the car would return, up would go the hood again and there would be more tinkering. Then the whole crew would disappear into the barn again.

If you knew anything about Dayton, you probably were aware that the barn belonged to Edward A. Deeds, who was general superintendent at The National Cash Register Company, Dayton's fastest-growing industry. The young man at the barn who seemed to have no other home was C. F. Kettering. He also worked at "The Cash," as an inventor, or at least he had worked there, before he quit to devote full time to whatever was taking place in Deeds' barn. As for the rest of the "barn gang," they represented many different skills and trades and they came from all over Dayton.

The men working in the barn were out to lick a bugaboo which plagued all automobile owners of that time—that of poor ignition. It was a problem the motor-car manufacturers had not been able to solve. Although engines were steadily improving and the auto making great strides in many other directions, for want of a fat, healthy spark in the cylinder at the proper moment, cars periodically snorted, bucked and stalled.

Two types of ignition systems were then in use, and both were regarded as villains by the harassed drivers who bore the brunt of their inadequacies. Operating on magneto, an engine would not run well at slow speeds in high gear. It often stalled, which meant getting out and struggling with a crank. This became particularly upsetting if a driver had to crank the car on magneto when the dry batteries of the auxiliary system had run down. It required a strong back and much patience. The battery system was equally unsatisfactory. It used dry cells in conjunction with a master vibrator to provide a shower of sparks. Like the old fashioned hot-water tank, the batteries were soon drained by the showering process. If a driver were lucky, a set of batteries might last all of 300 miles.

Cracking this problem seemed a natural for Kettering. During his years at The National Cash Register Company the young inventor had been up to his ears in the complexities of electrical relays and other devices designed to make the elusive electron behave in a practical way. Why not substitute some kind of controlling relay for the vibrating coils? The result should be a single, hot spark in the cylinder in place of a shower of feeble ones. Not only would an engine run better if such a system could be devised, but it should also prolong the life of the dry cells.

This objective, then, was to comprise the first act in the drama of the barn. It was a project worthy of the earnest agreement reached earlier by Kettering and Deeds—and sealed only by a handclasp—to "put something on a car." Had the two men realized how elusive that goal was to become during various stages of the barn saga, however, they might have been tempted to direct their talents and money elsewhere.

At the beginning it had appeared deceptively simple. In a short time Kettering had completed an experimental ignition system incorporating his ideas for producing a better, more economical spark. The system worked beautifully. On a test run, Deeds drove all the way to New York and back on a single set of dry cells and there was still life in the batteries at the end of the trip. Besides having an idea, the partners now had a vastly superior product.

They inevitably turned toward Detroit which by then was well on its way to becoming the motor capital of the world. In that maelstrom of feverish automotive activity it should not be difficult to find a manufacturer who would be quick to see the merits of the Kettering system.

Henry M. Leland, "Uncle Henry" to the trade, was such a man. Distinguished in appearance, the white-bearded Leland had brought dignity and integrity to an industry that was noted for the lack of both. Into his Cadillac automobile, Leland had poured a lifetime of experience and sound engineering practice. In describing Leland as an institution, not just an auto-maker, one of his associates said the old gentleman's "first and last concern was the absolute rightness of everything," even to the exclusion of making money.

It had been Leland who had jarred the smug Royal Automobile Club out of complacency by shipping three Cadillacs to England and having them disassembled and all of the pieces piled into one heap. Then, while the astonished Europeans looked on, Cadillac mechanics reassembled three cars from this jumble of parts. Thanks to Leland's obsession for absolute perfection of manufacture, the Cadillacs reassembled from this hodge-podge of pieces ran perfectly. "Uncle Henry" in one stroke had pointed the way to the standardization of parts that was to make the motor car a practical conveyance for all, not just a luxury for the few.

To sell the Kettering ignition system to Cadillac would represent more than obtaining a market; it would bring prestige overnight to an unknown invention that had been sired in a barn by a small band of neophytes in the industry.

Down from Detroit came Leland's chief engineer for a test ride in the experimental car which Kettering and Deeds had equipped with the new ignition system. For several hours the Cadillac executive was jounced over every rough mile of road in the Dayton area and hauled up and down hills over Kettering's public proving ground. The new ignition system met every expectation. By the time the Cadillac engineer was finally safely deposited at the railroad station he was as thoroughly sold on the Kettering ignition system as were its hard-up promotors. Had he stayed in Dayton a few minutes longer, however, the story might have been different. When Kettering and Deeds tried to restart the car at the depot nothing happened. Kettering's slam-bang test run had finally taken its toll; a small wire had snapped. It was fortunate that at the time of the breakdown the Cadillac engineer was riding the train back to Detroit.

Henry Leland was a man of action as well as perfection. When a complete Kettering ignition set was sent to Detroit and successfully tested there, the elderly manufacturer summoned Kettering and Deeds to his factory. Yes, Cadillac could use 5,000 ignition sets. A secretary produced a contract and Kettering and Deeds suddenly found themselves in business.

There were complications. Kettering and Deeds had no company. They had no factory and no formal organization. Yet Leland went ahead and announced that the new ignition system would appear on the forthcoming 1910 Cadillac. Clearly, it was a time for action if the Kettering-Deeds venture was not to be swamped before it even got started.

William A. Chryst, who had been Kettering's chief lieutenant during his years with The National Cash Register Company, supplied the name for the new firm which was incorporated July 22, 1909. In its abbreviated form of "Delco," the Dayton Engineering Laboratories Company was later to become known the world over for a wide variety of products.

Since the barn project was originally conceived of as an "idea hatchery" rather than the nucleus of a factory, Kettering turned to a Chicago electrical manufacturer for actual production of the new Cadillac ignition sets. With this arrangement, the last hurdle had apparently been cleared.

Then bad news came from Detroit. Could Kettering come at once? Arriving at the Cadillac plant, Kettering found the top brass, including Uncle Henry, in an unhappy frame of mind. They had received the first ignition sets from the manufacturer and there was trouble aplenty. The controlling relays, the heart of the Kettering system, were sticking, and nobody seemed to be able to do anything about it. The first 1910 Cadillacs were almost ready to be shipped to dealers for advance showings. The unexpected trouble could not be solved in months, or even weeks—it had to be eliminated in a matter of days. If Kettering couldn't fix the ignition sets at once, the new system would have to go by the board.

That afternoon at the Cadillac plant Kettering tried almost everything, to no avail. Exhausted and apparently defeated he caught a late train back to Dayton. He carried with him one of the ignition sets, hoping that the barn gang might help him solve the mystery. Unable to sleep on the train he reached into his bag and pulled out the relay. In the dark his fingers moved over the pole pieces and the armature. Suddenly he knew what was wrong. The pole pieces had not been machined perfectly flat, and this had changed their magnetic effect. Getting off the train he hurried to the barn, machined down the offending parts and headed back for Detroit on the next train. The relay dilemma was ended.

If the whole venture was now assuming a Hairbreath Harry quality it was not Kettering's fault. Another urgent wire arrived from Cadillac. This time the new ignition system would provide a wonderful spark for a time and then suddenly peter out. Again Kettering hurried to Detroit and again he tinkered futilely with the test car there. Back to Dayton he came, rushing to the barn. He knew the trouble was somewhere in the coils, but it could not be found. His mind spinning from theories and lack of sleep, Kettering tested the coils in all the different ways he knew, trying everything. He was adjusting the spark gap when suddenly the spark grew weak. Then he did a simple thing. He switched the wires leading from the dry cells, so that the positive pole became negative. The "corona effect" which had been causing the trouble immediately disappeared. With it went the last major obstacle to Delco's success.

The 1910 Cadillac appeared with the promised revolutionary ignition system and owners loved it. The frown on Henry Leland's face was soon replaced by a broad smile as congratulations poured in, and he was wont to refer to Kettering as that "absolutely unknown young electrical genius."

Now Leland turned to Kettering for help in the biggest problem faced by the industry. As a result of its new ignition system, the Cadillac was the smoothest running car of its time. But like every other automobile it had to be cranked with resulting peril to life, limb and temper.

To Henry Leland the crank was a symbol of all that remained to be done in perfecting the automobile. He viewed this ugly but necessary instrument as a personal affront, not to be tolerated any longer than necessary. When six of his workmen broke their arms cranking Cadillacs Leland became even more upset. The peak of his crank-phobia was reached, however, when another auto manufacturer—a close friend—suffered a broken jaw while cranking a lady's stalled car on the Bell Isle Bridge. The victim died sometime later and Leland affixed the blame squarely on the crank.

"Something must be done about it," he told Kettering. "I am breaking arms all over the country and it has got to stop."

Fresh from the ignition triumph, Kettering was ready to tackle almost anything.

"I don't believe it would be too difficult to crank a car by electricity," he said.

That was all Leland needed. "If you can provide a practical self-starter, I'll put it on the 1912 Cadillac," he promised.

Thus the barn gang found themselves embarked on an entirely different and more exacting project, even before their former one had cooled off. On the train back to Dayton — he was becoming by this time almost a daily commuter—Kettering thought over the problem. Back in the baggage car rode a new Cadillac engine to experiment with.

The self-starter was something about which there had been much talk but little action. Inventors had already devised starters that operated from coiled springs, from compressed air or by means of various gases, but none of these had proved satisfactory.

The next morning the barn gang routed out an implement dealer who had a varied supply of sprockets, chains and gears. They rigged up a test mechanism to establish whether an electric motor, properly geared, could actually turn over the Cadillac engine. When the last connection was made late in the afternoon Kettering took a deep breath and turned a switch. Then he relaxed. The engine was being cranked successfully by electricity; an electric self-starter was practical from a quantitative standpoint. Now the real work could begin.

The first problem was simply one of size. The test apparatus which had proved an electric self-starter was feasible sprawled all over the barn. If there was to be any room for passengers in a car equipped with a self-starter "The Boss" and his crew would have to perform a miracle of shrinkage.

Most of the members of the barn gang have at one time or another described the ensuing weeks and months. Their accounts vary, but one impression weaves through their narratives consistently. "The Boss" and his helpers had never experienced anything like it before, and few ever wanted to go through it again. Days ran into nights and dates became jumbled beyond recall. Inevitable false starts were made and then steps retraced. Domestic relations became strained as husbands and fathers frequently worked 24 to 36 hours without letup. It was hot that summer in Dayton and the haymow of the barn was almost unbearable, but a huge, never-empty pitcher of lemonade and an old, battered phonograph helped keep the men going.

By October the Cadillac Motor Car Company was growing impatient. From Detroit came a polite, but firm reminder that if the self-starter was to appear on the 1912 Cadillac a test model would have to be completed soon. The barn gang had better get a move on.

It was difficult to explain to the people in Detroit that there were limits. The battery dilemma, for example, was typical of the seemingly endless series of roadblocks faced by Kettering and his helpers. Without a suitable battery the Kettering self-starter would be a complete washout, yet battery manufacturers had shrugged off the possibility of ever developing a battery that would do the job Kettering demanded.

One company, however, sent to Dayton a salesman to look into the outlandish project, to talk with these men who were attempting to do the impossible. The salesman, O. Lee Harrison, found Kettering alone in the shabby little office Delco maintained downtown, his feet propped up on the desk.

Harrison came right to the point. He said, in effect, that his company had never heard of anyone wanting 5,000 batteries at one time, as Kettering had mentioned in a letter. Now, in the ridiculously small office, talking with the lanky fellow wearing an old golf cap, it seemed even more far-fetched than ever.

Kettering then took Harrison to the barn and showed him what had been accomplished. A few hours later the battery salesman climbed aboard a train headed for his company's home offices. He was now a self-starter convert in the worst way, and if his company refused to play ball with the barn gang, Harrison stood ready to resign and find a battery manufacturer who would. Fired by missionary zeal, Harrison stormed into the battery factory and had built under his personal supervision a lightweight battery of the power and capacity that the barn gang needed.

But all such hurdles took time to surmount, and time was the one thing Kettering needed more of. One week before Christmas in 1910, another crucial test took place. The first self-starter had been completed and fitted to the Cadillac test engine. Kettering crossed his fingers and sent the current into the circuit. The starter failed to operate. A second and a third trial, and then several more produced the same results.

The trouble was finally traced to a faulty armature and on the night of December 17th the Kettering self-starter was successfully operated for the first time. The barn gang had apparently done it; what worked on the engine alone was sure to work in a complete automobile.

At least they were left with that pleasant thought for a few days, but the dream was shattered suddenly when a new Cadillac car was sent to Dayton to be fitted with the new starter; the Detroit engineers had not left enough room to squeeze in the starter that now stood useless.

New drawings, new designs, new castings and machinings had to be rushed through. Then in February Henry Leland suddenly announced that he was leaving for Bermuda in a week. If the self-starter could not be tested before then, he was afraid it would have to be abandoned, at least as far as the 1912 Cadillac was concerned.

The following days made the previous months of hectic effort seem vacationlike. Kettering and his aides labored around the clock. Despite fantastic consumption of strong coffee and the additional stimulus of an absolutely inflexible deadline, members of the barn gang fell asleep on their feet, yet somehow the work went on.

The day before Leland's scheduled departure, the last wire was connected in the experimental car and Kettering pressed the starter button.

There was dead silence.

No one could discover what was wrong. Minutes of checking circuits and parts stretched into hours. For the first time "The Boss" seemed defeated. Then someone suggested calling Chryst, who had retained his job at The National Cash Register Company during the barn experiments. Maybe he could solve the trouble that had completely stumped the exhausted workers at the barn.

It was an invaluable suggestion. Two small wires had been connected incorrectly during final assembly of the starter. Chryst spotted it at once. This time, when the starter button was pressed, the Cadillac engine turned over and then the barn gang heard the very pleasant sound of it roaring into life. The test car was rushed to Detroit; "Uncle Henry" Leland was pleased.

Unfortunately, the car caught fire in Detroit a few days later, damaging the starter, and another SOS came from Detroit. Kettering was needed at once if necessary tests prior to acceptance were to be completed. At the moment "The Boss" was lying in bed, where he had been ordered to remain for a week, with a broken ankle suffered when his test car slid into a ditch.

Again he hurried to Detroit, his leg in a plaster cast. Again the trouble was overcome. Then a mysterious coil difficulty appeared. Once more a crisis was met and surmounted.

After Cadillac had finally accepted the self-starter, more months of hectic work remained. Unable to find a manufacturer who would produce the complete self-starter the tiny Delco organization had to subcontract various parts and establish an assembly plant in Dayton. The resulting switch from experimental laboratory to factory was not an easy one — both Kettering and Deeds mortgaged their homes and borrowed money on their life insurance to raise the necessary capital.

Vindication of their faith in the self-starter came with the introduction of the 1912 Cadillac, however. That year the Cadillac Company received the Dewar Trophy, highest award in the industry, as a result of its revolutionary new feature. By 1913, almost half the motor cars on the market had been equipped with self - starters, and this percentage climbed to 90 per cent a year later. In one stroke, the little group of men working in a barn had brought about a motoring revolution without parallel in the history of the industry.

Some time later, Kettering was addressing a group of eminent engineers on the development of the self-starter and the principles of its operation. From the audience arose a distinguished-looking man who was obviously quite agitated.

"Mr. Chairman," he said with emotion. "I move that this meeting be adjourned. Obviously, this gentleman doesn't know what he is talking about. He has profaned every law of sound engineering practice. No wonder his self-starter works!"

It was one of the nicest unintentional compliments "The Boss" ever received.

Kettering on "Intelligible" Talk

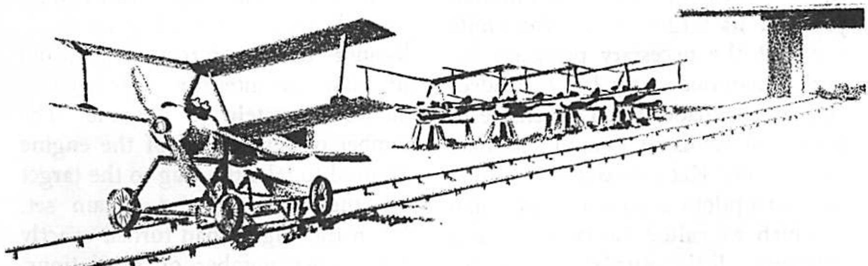
"A friend of mine was complaining about the technical fellow who doesn't know how to talk intelligibly. Then he cited the case of an English teacher he knew:

" 'Now, George,' he said, 'has the greatest command of English in the world.'

"So I asked, 'Well, what does he say?'

"He answered, 'Oh, he says absolutely nothing, but he does it superbly well.' "

—From a recent speech.



The First Buzz Bombs

One of the most remarkable of Boss Ket's achievements was the secret World War I project which fathered the world's first pilotless aircraft. Many years later—on the eve of our entry into World War II—the so-called "Bug" was again seriously considered as a possible weapon for our Air Force. However, the geographical distance of interior Germany from English bases made it impractical as a weapon for the Allies.

By General H. H. Arnold

From his book, "Global Mission," Published by Harper & Brothers

CHARLES KETTERING OF DELCO was a man who did all kinds of "impossible" things. Whatever the problem, he made it seem simple. Exactly one week after Eisenhower's troops hit the Normandy beaches on D-Day, the world was horrified by the sudden appearance over London of the first V-1's, the gruesome pilotless buzz bombs. A number of people in this country, including Ket, were not surprised, for he and our own Air Force had fathered, if not invented, this weapon back in 1917.

Early in the fall of that year, working with the Sperry Company, and with Ket's Delco firm, we had developed—not merely experimented with, but successfully tested — two pilotless planes. One was a full-sized airplane, but equipped with complete gyroscope controls, built at Sperry's Long Island plant. Further tests in the spring of 1918 showed that this flying bomb was sufficiently accurate to reach a point within a hundred yards of its target after a forty-mile run, but the necessary precision devices, man-hours to be expended, and so on, made it too expensive to pursue in terms of quantity production. Under Ket's direction, we then devised a pilotless airplane—or bomb—which we called the Bug. It was a complete little airplane built of papier-mâché and reinforced with wooden members, its smooth cardboard wing surfaces spreading less than twelve feet. Its fuselage held 300 pounds of explosives and it weighed, unloaded, 300 pounds itself. It took off from a small four-wheeled carriage which rolled down a portable track, its own little two-cycle 40 h.p. engine, built by Henry Ford, meeting the requirements for both pressure and vacuum necessary to operate the automatic controls. The actuating force for the controls was secured from bellows removed from player pianos. They rotated cranks, which in turn operated the elevators of the rudder. The direction of the flight was insured by a small gyro, elevation from a small supersensitive aneroid barometer, so sensitive that moving it from the top of the desk to the floor operated the controls. This kept the Bug at its proper altitude. At first we relied only on the dihedral of the wings for lateral stability, but later, more positive directional controls had to be installed with orthodox ailerons. Including the $50 gasoline engine built by Ford, the entire device cost about $400.

To launch the Bug, tracks were pointed toward the objective. The distance to the target, and wind direction and intensity, were figured out as accurately as possible. The number of revolutions of the engine required to take the Bug to the target was then figured, and a cam set. When the engine had turned exactly that proper number of revolutions, the cam fell into position, the two bolts holding on the wings were withdrawn, the wings folded up like a jack rabbit's ears, and the Bug plunged to earth as a bomb. (In 1944 the German V-1's flew to their objectives on similar principles, insofar as range was concerned.)

Our first tests being highly successful, we decided to demonstrate the Bug to the top Washington brass, and invited them to Dayton, Ohio. With the care that goes with such occasions, it was decided that only enough gasoline would be put in the tank to allow the Bug to leave the track and make a straightaway flight of two or three hundred yards at most. Unfortunately, not even Kettering realized how little gasoline the Bug needed to operate. After a balky start before the distinguished assemblage, it took off abruptly, but instead of maintaining horizontal flight, it started to climb. At about six to eight hundred feet, as if possessed by the devil, it turned over, made Immelmann turns, and seeming to spot the group of brass hats below dived on them, scattering them in all directions. This was repeated several times before the Bug finally crashed without casualties.

Ket put ailerons with proper controls on it and a second show was set up. This time, we believed the Bug would fly straight for a mile or so at about 50 miles per hour, so we loaded the high-ranking visitors into automobiles to follow it and be present when it crashed. Everything looked perfect for the test. The efficiency of the flying bomb was now a certainty. Our one fear was that information about it might leak out to the Germans. Again it got away, but this time only because it was too fast for the automobiles to keep up with. However, instead of flying straight, it made a circle around the city of Dayton. We had to get to that wrecked Bug before anyone else. In the vicinity where we thought we had seen it come down, we came upon some excited farmers. "Did you see an airplane crash around here?" we asked. One farmer said, "Right over there! But strange thing, there's no trace of the pilot!" Colonel B. J. Arnold, the Army officer in charge of the project, remembered quickly that we had a flying officer in a leather coat and goggles in the car. "Here's the pilot," he said. "He jumped out in his parachute back a piece. Let's go pick up that wreck." Our secret was secure. The awed farmers didn't know that the U. S. Air Corps had no parachutes yet.

The Bug was twenty-five years ahead of its time. For all practical purposes—as a nuisance weapon—it compared very favorably with the German V-1. It was cheap, easy to manufacture, and its portable launching track would have permitted its use anywhere. Considering the trends in air weapons today, and that the first German V-1 was not launched against Britain until the fifth year of World War II, it is interesting to think how this little Bug might have changed the whole face of history if it had been allowed to develop without interruption during the years between the two wars. It was not perfect in 1918, of course, and as new gadgets and scientific improvements came out they continued to be incorporated into the Bug until the economy wave of the mid-twenties caused it to be shelved.

(Editor's note: The Bug was revived another generation — and another World War—later. In another chapter of "Global Mission" General Arnold continued his account of this weapon, as follows:)

There was a possibility that we now (1941) had something still more useful (than the B-17 bomber) in our air power arsenal, when and if we entered the war against Germany. The "something" was nothing less than a highly improved version of that same little pilotless Bug which we had devised in 1916-18 and had kept on developing as well as the strict attention to "Economy in Government" permitted.

Recently revived trials indicated that the Bug was now ready for operational use. Its flight-tested range, in December, 1941, was better than 200 miles, both this and its accuracy apparently being capable of rapid improvement. It might be necessary to change the original concept. It was now controlled by radio. We could employ one of the many other modern scientific devices that would insure it a direct-reckoning course to its objective. The pilotless Bug was, in any case, already a modern military weapon in being. It would cost, per unit, between $800 and $1000 as compared to $200,000 for a medium, or $400,000 for a single heavy bomber, and could be produced quickly in large numbers . . . It can be imagined that in December, 1941, the Bug seemed a very tempting proposition.

I called a meeting at which only Kettering, Bill Knudsen and myself were present. We discussed the availability of bases; of targets; the cost; production; comparison of production between the Bugs and heavy bombers; raw materials needed for the two types of weapons. We finally came to the conclusion, unanimously, that even with the most improved type of Bug, the best we could do from England would be to hit Paris, or some of the other large cities in France, Belgium, or Holland. We could not get at the real heart of our enemy—interior Germany itself.

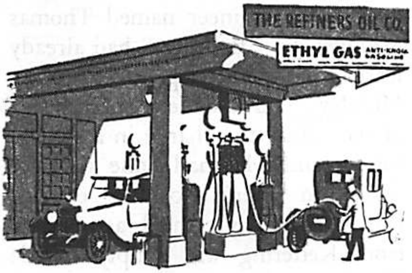
Had we been in the position the Germans then were, and had the Germans instead of the English inhabited the British Isles, the story would have been very different. We could, and we would have concentrated the flight of thousands upon thousands of these Bugs on practically all the interior of southern and middle England, including the key industrial areas. We could probably have had this assault in full swing by late 1942 or early 1943, and have used the Bug by the thousands and tens of thousands. The Germans could have done little to stop it. As it was, the first pilotless bomb did not buzz across the English Channel from a German launching site until the night of the 12th of June, 1944, a week after our ground forces had landed in Normandy, and two and a half years after Kettering, Knudsen, and I held this discussion in my office.

The Screwdriver-Pliers Type

"There are two kinds of people in my book: those who work at desks with pencil and paper—the businessman, the executive, the planner—and the ones who work on the bench with screwdrivers and pliers. I'm the screwdriver-pliers type. I have never done anything at a desk in my life, because I found out that whatever I thought I could do there wouldn't work down at the bench. So I started on the bench first and worked back up the other way. You have to do these things the way they will work."

—C. F. K.

THE EVOLUTION OF "ETHYL"



An early blooming wild flower would seem to have little connection with eliminating knock in auto engines. Yet the trailing arbutus led to an important discovery in solving the mystery of how to make knock-free gasoline.

ON A GREY winter day in 1923 a Dayton, Ohio, motorist swung his Buick touring car into a filling station where a bold, freshly painted sign had been hung only a short time before. The sign read:

ETHYL GAS
ANTI-KNOCK GASOLINE

The motorist, F. M. (Mike) Redelle, was not aware that he was making automotive history. He simply needed gas. Also, his Buick was a likely candidate for any brand of gasoline that might eliminate its noisy ping.

His car's tank filled, Redelle again pulled out into the early-morning traffic. The Buick was running more smoothly than it had for months. The knock had vanished. Without knowing it at the time, Mike Redelle had been the first man in the world to buy a tank of "Ethyl" gasoline.

Behind that sale lay one of the great technological stories of the 20th Century. "Ethyl" gasoline had been born of a challenge. The labor pains of its birth had been long an intense. And even though the relatively few men who had brought Ethyl into existence were jubilant that morning, their new product was to face still further tribulations before it was to reach its full maturity.

The story of Ethyl is a vindication of the scientist's thesis that the solution of one problem often presents another. In the case of Ethyl, the original problem had been Charles F. Kettering's. "Boss Ket" had solved this problem, that of providing better lighting for remote farm areas, by combining an internal combustion engine with an electric generator. His Delco farm lighting units were selling by the thousands, but there was just one trouble. When farmers tried to run the engines on kerosene instead of gasoline the "coal oil" knocked the living daylights out of them.

Nor was that the only occasion on which engine knock had come to haunt the youthful inventor. A few years before, the superior Kettering battery ignition system had replaced the magneto on the Cadillac automobile. In addition, Kettering had been instrumental in Cadillac's introduction of the first American V-8 engine in 1914. This engine was revolutionary and its performance sensational by pre-World War I standards. But there was one bothersome detail to be licked . . . an annoying ping that developed whenever the driver tramped down on the accelerator.

Kettering had been getting the blame. It's that battery ignition system, many people said. A magneto wouldn't do that. Others pointed to the Cadillac engine itself, saying it might be powerful and it might be efficient, but there was obviously something wrong somewhere.

Thus, knock had come home to roost on Kettering's doorstep. Whether or not he deserved the problem it was always there, staring at him day in and day out. Countless little reminders kept prodding at him. The "spark knock" that was irritating Cadillac owners and cracking cylinder heads on Delco light plants was for most practical purposes a Kettering knock. It was a challenge that Kettering felt he must meet.

One of Kettering's assistants at Delco in 1916 was a 27-year-old graduate of Cornell University, a mechanical engineer named Thomas Midgley, Jr. "Boss Ket" had already learned he could depend on young Midgley, who had developed a way of measuring the charge in a storage battery and who had done valuable work on mercury-cooled exhaust valves. Midgley's third assignment from Kettering was simply stated: "Find out what causes engine knock and then find some way to eliminate it."

So Midgley set out on the trail of knock. He was to get outstanding assistance along the way from his co-worker, T. A. Boyd, and from such brilliant chemists as Carroll A. Hochwalt and Charles A. Thomas, and finally from Kettering himself. How much Midgley depended on "Boss Ket" he once summed up in this way:

"I am not overstating the case when I say that everything I have ever done, everything I have ever accomplished worthwhile has been done under the magic spell of his inspiration."

It was like the "beautiful theory" of the trailing arbutus. From some long forgotten experience of the past, Kettering suddenly remembered one day the trailing arbutus. The arbutus was always the first flower to bloom in the spring, sometimes even before all the snow had melted in the woods around Kettering's boyhood home. From a lifetime devoted to answering "whys" Kettering automatically wondered about the arbutus. Maybe its early blooming had something to do with its color. The leaves of the arbutus are flecked with red. Perhaps for this reason the arbutus absorbed the feeble spring sunlight better than other plants. Maybe it simply stored more heat than its greener neighbors.

Then take it one step further. If the red causes the arbutus to absorb heat, maybe red would absorb heat during combustion in an engine cylinder, thereby smoothing out the burning of the fuel, eliminating uneven combustion and, most important of all, engine knock.

Kettering told Midgley about the arbutus leaves on a Saturday afternoon. Midgley went straight to the stockroom and asked for a red dye. Luckily, the stockroom had no red dye and with the stores closed there was no chance of getting any until the following Monday. But Midgley was too impatient to wait. Wasn't there anything around that would produce a reddish color? The stockroom attendant looked up and down the shelves. Would iodine do? Midgley wasn't sure, but at least it was soluble in kerosene and would produce a reddish-brown tint. It seemed worth trying.

Then the miracle happened. Run on kerosene alone the little test engine clattered and hammered. A few drops of iodine, however, and the knock magically vanished. Midgley had found an anti-knock agent, thanks to Kettering's remembering the arbutus and then coming up with a theory. It seemed too good to be true, and of course it was. The trouble was that Kettering's theory was wrong. Midgley found this out the following Monday when he rushed to the stores and bought many different kinds of dyes. Not a single one of them reduced engine knock in the slightest. The iodine had eliminated engine knock because of its chemical characteristics. The fact that it gave the kerosene a reddish color had absolutely nothing to do with knock.

If the theory was wrong, there was still iodine; it had stopped engine knocking miraculously. But once again Midgley knew it was not—could not—be that simple. In the first place iodine cost too much; it would never be economically feasible as a major ingredient in gasoline. And there was an even more serious drawback. Iodine turned an auto engine into a little chemical factory which made iodides of various kinds. These compounds would ruin an engine in almost no time.

Kettering had been up blind alleys before. In this letdown following the elation which had followed the iodine experiment, he was not greatly concerned. As he said later:

"Our early work was mostly a succession of failures, with just enough successes to keep us going . . . in doing a new thing which has no precedent whatever, only occasionally does anything go right; and at least 90 per cent of the time it goes wrong."

One of the few things that had gone right in the fight against knock up to that time had been the development of the Midgley Indicator. This was a recording device which showed the pressure curve of fuel explosions in a test engine. From it, the research team at least had laid to rest one recurrent bugaboo — that knocking was caused by pre-ignition. By installing a quartz window in the side of a test engine, Kettering and Midgley also had for the first time actually watched combustion take place. They literally knew what "knock" looked like.

Now, thanks to the iodine, they had a new lead. Knock could be eliminated by adding a chemical to gasoline. And even though iodine was not satisfactory, perhaps another chemical with similar characteristics would be. Acting on this hunch, they began the long and discouraging search, in and out the thousands of chemical byways that offered hope.

Repeatedly, their budget was exhausted; repeatedly they asked for—and got—more funds from General Motors, whose management maintained its faith in the ultimate success of the project.

On a day five years later, that faith was justified. The anti-knock researchers synthesized a single spoonful of tetraethyl lead and tried it in a test engine. Again the noisy knock disappeared, just as it had on the exhilarating day when iodine was tried by accident. This time, however, Kettering and Midgley had a truly practical anti-knock agent. It was the decisive victory, but little time was spent on celebration. Midgley said later:

"The popular idea might be that when we found tetraethyl lead we shouted hosannas for it, and all marched in to ask the boss for a raise. Actually, there wasn't a pause in the program. We started spending more money, doing more research, and looking for other ingredients to go with tetraethyl lead, to make up a commercially practical compound."

The researchers ran squarely into another snag. They discovered that they would need huge quantities of ethylene dibromide to mix with the tetraethyl lead. The purpose of the ethylene dibromide was to combine with the chemical by-products created when combustion took place in gasoline which had been treated with tetraethyl lead. Otherwise, gasoline containing tetraethyl lead dissolved spark plugs.

Bromine was expensive. Its chief use at that time was in making photographic plates and headache powders, and the only known major supplies were the brine wells of Michigan. Unfortunately, the whole state of Michigan would be unable to supply the anticipated needs, so Kettering went to Tunis to investigate bromine supplies there. Other parts of the world were also carefully checked. None proved feasible as a source of bromine in vast quantities.

The research team had one other possibility. They knew that the sea contained billions of tons of bromine; the problem was how to get it out at reasonable cost. In 1,000,000 parts of sea water, there were only 67 parts of bromine. The "experts" consulted their slide rules and shook their heads. It couldn't be done economically, they said.

Typically, Kettering distrusted this verdict. He and Midgley acquired a former Great Lakes steamer which they fitted with special equipment for taking the bromine out of sea water. The steamer cruised the waters of the Gulf Stream and the equipment was tried out. The experiment itself lasted only six hours. Since the steamer and its equipment had cost $360,000 the cost per hour was $60,000. The money was well spent. The S.S. Ethyl proved that bromine could be taken from the sea, and at a price that was economically justifiable.

More than a year passed before the first gallon of "Ethyl" gasoline went on public sale at the little service station in Dayton. During this time tetraethyl lead was perfected as an anti-knock agent, it was thoroughly tested in the laboratory and on the road, and methods for its industrial manufacture were devised.

Emerson's mousetrap dictum to the contrary, the world did not beat a path to Ethyl's door. Except for its developers, the new product failed to arouse much interest among gasoline refiners. Eventually however, Midgley interested the independent Refiners Oil Company in test-marketing "Ethyl" gasoline in Ohio. After the first sales in Dayton, Refiners extended the marketing to other stations. By mid-summer of 1923, each of the firm's 75 stations was selling Ethyl. Refiners had scored one of the greatest marketing scoops of the era; the company was the talk of the oil industry.

Ethyl won new fame on Memorial Day of 1924. The cars which finished first, second and third in the grueling 500-mile Indianapolis auto race all used "Ethyl" fluid to make possible increased power and smoother running. Also in 1924 the Ethyl Gasoline Corporation was born as successor to the General Motors Research Corporation and the GM Chemical Company which had marketed Ethyl previously.

Then more trouble arose. In 1925 charges were made that "Ethyl" gasoline was a public health hazard. It was referred to as "loony gas" by its detractors. The infant corporation acted boldly and decisively in the face of this "poison scare." On May 5, 1925, its Board of Directors voted unanimously to take Ethyl off the market while the charges were thoroughly investigated.

The investigation, conducted by the United States Public Health Service, lasted almost a year. It found that there were no good grounds for prohibiting the sale of Ethyl provided proper safety regulations were followed. Ethyl had won a clean bill of health. By 1927 it could be bought anywhere in the nation.

Other milestones followed. In 1933 Ethyl fluid was made available for "regular" gasoline as well as premium quality. In 1935 the first high-compression tractor opened broad new markets. A year later Ethyl Corporation's present manufacturing facilities were first established at Baton Rouge, La. Between 1946 and 1952 Ethyl Corporation invested more than $100,000,000 in expansion and improvement of its manufacturing facilities to keep pace with demand, including construction of a new plant at Houston, Texas. Today Ethyl is the world's largest producer of anti-knock compounds. More than 500 billion gallons of motor and aviation gasoline have been improved by the addition of Ethyl fluid since the first spoonful was made late in 1921. Meanwhile, manufacturing economies have reduced its cost to about one fifth of its original selling price.

Like most industrial success stories, the story of Ethyl has many overtones of economic and sociological significance. By reducing fuel knock, Ethyl has made possible more powerful engines and more efficient utilization of the world's fuel resources. It has been estimated that this whole development has saved the public about one third of the total gasoline costs it would otherwise have paid down through the years had an anti-knock agent never been discovered.

On the occasion of C. F. Kettering's 75th birthday in 1951, Ethyl Corporation said of his role in Ethyl's evolution:

"He conceived its need, supervised its discovery, fought its failures, preached its virtues, and dreamed its destiny. He even chose the name and wrote the first advertising. As might be suspected, he is rather proud of how things have worked out. He has always had a very warm spot in his heart for 'Ethyl'."

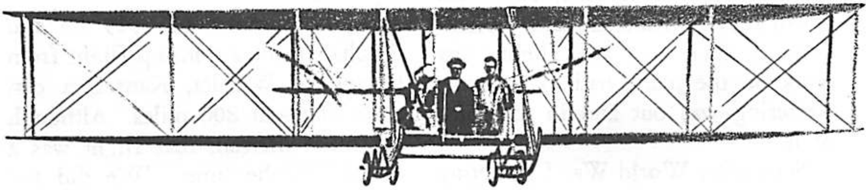
The Ethyl Corporation wanted "Boss Ket" to know that as far as its 6,000 employees were concerned, the feeling was mutual.

Kettering's Definition of Research

"Research is a high-hat word that scares a lot of people. It needn't. It is rather simple. Essentially, research is nothing but a state of mind —a friendly, welcoming attitude toward change . . . going out to look for change instead of waiting for it to come. Research, for practical men, is an effort to do things better and not to be caught asleep at the switch. The research state of mind can apply to anything: personal affairs or any kind of business, big or little. It is the problem-solving mind as contrasted with the let-well-enough-alone mind. It is the composer mind instead of the fiddler mind. It is the 'tomorrow' mind instead of the 'yesterday' mind."

—C. F. K.

Boss Ket's interest in aviation goes back to the days when you sat out in the breeze with "a couple of sticks in front of you." Although he was one of the pioneers of flight, his role as an aviation booster, pilot and even airplane designer is not widely known.



"I Am An Old Pilot"

Excerpts from the forthcoming book, "Professional Amateur, a Biography of Charles Franklin Kettering", by T. A. Boyd
To be published in January by E. P. Dutton and Company

BECAUSE Kettering lived in Dayton and knew the Wright Brothers he early became interested in flying. His first airplane flight was made at the flying school operated by Orville Wright, with Howard M. Rinehart as pilot. The place was near Dayton on the site of what is now Patterson Field, and the time about 1912. As Kettering recalls it, the airplane in which he was given his first flight was "one of the very old Wright models where you sit out in front with a couple of sticks in front of you."

Kettering had the greatest admiration for Wilbur and Orville Wright and for all they did in overcoming obstacles in the way of successful flight. Those obstacles were psychological as well as physical, for it was commonly believed then that heavier-than-air flight was impossible. "The Wright Brothers," Kettering said, "flew right through the smoke screen of impossibility."

He soon became enthusiastic about flying. With Rinehart as pilot, he did a great deal of it. At that early time when the airplane was in its infancy, said Rinehart, few other men of Kettering's prominence were flying. People thus talked about his flying exploits, and what he did and said had a large influence in furthering interest and advancing activity in aviation. "This thing is coming," Kettering would say. "There isn't anything to stop it . . . We must accept it with an open mind." He overlooked obstacles, of which there were many at that time, and went ahead anyway, Rinehart said. Whenever in their airplane flights any work on the plane had to be done, Kettering was out and in the thick of it.

Soon after World War I Kettering made up his mind to learn to fly an airplane himself. And B. L. (Benny) Whelan, then a pilot for the Dayton-Wright Airplane Company and now general manager of Sikorsky Aircraft, undertook to teach him. Kettering was a different student from any other he had ever taught, Whelan remembers, in that he came nearest to knowing beforehand how to pilot an airplane. What he needed most was some practice. Of actual instruction he had to have only a very little.

For a long period after learning to fly Kettering used to get up early and take his plane into the air, which he did in many kinds of weather. He went up to study the weather and air currents, in fact. He would keep his plane sitting out, waiting for word from the Weather Bureau, whom he had asked to let him know when there was to be some special weather, such as when it was going to hail.

Nevertheless he was a careful flier, one who did not do any stunting. "There is just as much sense to stunting in an airplane," he said once, "as there is to running down the street, putting on the brakes and skidding around the corner." He said too, "I have always had a rule for myself. Never fly when the birds don't, because they have had a lot of experience."

In the summer of 1919 he and Rinehart made a nonstop flight from Dayton to Wichita, Kansas, a distance of about 800 miles. Although not made official, that flight was a record for the time. "We did not come from Dayton to Wichita by air to try a stunt," said Kettering in a speech he made there on that occasion, "but because the modern airplane is capable of making the trip and because people did not know that such a thing could be done."

"I made only two railroad trips last year," he said in 1920. "I flew more than 15,000 miles. I was not out joy riding. I was just at one place and wanted to go somewhere else, and I traveled in an airplane. Several years hence the aircraft industry will be a big business. It is in its infancy, but it is developing . . . A means of transportation three to five times faster than any other is a utility. It is such a great utility that we do not at first appreciate it."

Even in those years around 1920 before flying aids or even landing fields he was flying everywhere, and sometimes most informally. Benny Whelan recalled a time when Kettering's secretary, Charlie Adams, called him and said, "Boss Ket wants to go to St. Marys, Ohio. Will you please fly him up?"

When the time came, Kettering got into the plane and Benny took off for St. Marys. There was no landing field at St. Marys, but the landmark for the town was the lake to the west of it. Arriving over St. Marys, Benny found a field that looked all right, set the plane down, and taxied it to the corner nearest the town.

It was then that Boss Ket said to him, "Benny, do you know why I came up here? What did Charlie tell you? I have forgotten just what I am supposed to do here."

But at that point a group of men, who knew he was going to fly there and who had been looking for his plane, came up. From them it was learned that he was to be the guest speaker that evening at a meeting of the Idlewild Club.

He was one of the pioneers in improving the airplane and techniques of flying. Soon after he began flying he substituted a fuel pump for the pressure fuel system used on early airplanes and which was a dangerous feature of planes at that time. He was one of the first instrument fliers. In his plane he had a row of instruments, even though regular fliers at that time called it an old man's plane and said that anybody who used instruments in flying was a "sissy."

About flying under conditions of bad visibility, Kettering once remarked to another pilot in his roguish way, "If you should ever be in doubt throw out a monkey wrench. If it goes up, you are flying upside down. If it goes down, you are flying right side up."

He was an early advocate of radio-marked airplane routes and other aids to flying. "When we get this radio-marking across the country," he said back there, "it will be possible to take an airplane equipped with some new compass devices we already have and some other little trinkets developed during the war, put it on a course from Chicago to Dayton, and turn the flying of it over to the compass, which will do it better than we could anyway."

After World War I, an experimental airplane was built under Kettering's guidance and sponsorship, which had an all-cantilever wing structure. This was probably the first United States plane to have a practical retractable landing gear. Also, it was equipped with wing flaps which were possibly the first of the high-lift devices. This plane is now in the Edison Museum at Dearborn, Michigan.

After the General Motors Research Corporation was moved from Dayton to Detroit in 1925, Kettering flew back and forth to Dayton for awhile. Then in the late 1920's he quit flying altogether, and he did not take it up again for twenty years. Up to the time he quit, though, he had been flying so much and for so long that he is understood to have had then the most hours in the air of any amateur pilot.

After the death of Mrs. Kettering in 1946 and his retirement as head of research for General Motors in 1947, however, he began to fly once more. In 1948 he again got an airplane of his own. It is a Grumman Mallard, an amphibian which makes it possible for him to land on the water near his farm at Loudonville, as well as on regular airfields. He named his plane "The Blue Tail Fly," and, as a pioneer instrument flier, he had it equipped with the latest in instrumentation, including a telephone which he uses frequently.

In that plane he has since traveled wherever he needed to go. It has made him quite mobile and he does a great deal of flying about the country. Although he sometimes takes the control for a little while when in the air, he does not fly the plane himself but has it operated always by professional pilots. However, his interest in flying is so great that he has recently increased the number of planes he owns and uses to three.

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A Matter of Degree

To C. F. Kettering, the mere possession of knowledge is not enough; it is the ability to use knowledge that matters. To illustrate this point the inventor-scientist related the following anecdote during an address before a group of educators:

"We have in this country skills that are perfectly amazing, and a great many of our skilled people don't have college degrees. A friend of mine, who is head of the electrical engineering department of one of the big midwestern universities, said to me recently, 'Ket, I have a good story for you and it's on me. The other night my television went out. I did a perfectly normal thing. I took down the telephone and called for a serviceman. A nice young fellow came along with a box of tools and took off the back of the set, changed some tubes, and after a while had it running.

" 'You understand television very well,' I said.

" ' "Well, I have to," he replied. "That's my business."

" 'Did you go to the University?'

" ' "Oh, my heavens, no," he shot back. "I couldn't even get in the University. They wouldn't teach you anything about television anyhow. They teach you a lot of mathematical formulas. I can't understand that stuff, but I can understand television." '

"My professor friend added that the young repairman was making considerably more money than he was."

Kettering, who probably holds as many degrees as any man of his time, appealed to the educators not to degrade education "by running everything to a degree."

Detroit's Apostle of Progress

In 1919 C. F. Kettering became director of General Motors' research, with "no responsibility and no authority" other than to keep GM in the forefront of progress. His success in achieving this goal for more than a quarter of a century has benefited not only GM, but every person who drives an auto.

AN event of special importance in making Charles F. Kettering the world figure he is occurred in 1919. It was then that the men guiding the affairs of General Motors Corporation decided to set up a central research laboratory to help its several divisions improve their existing products, and also to develop new products. Among the men who made that decision were Pierre S. du Pont, chairman of the Board of GM; W. C. Durant, president; John J. Raskob, chairman of the Finance Committee, and vice presidents Alfred P. Sloan, Jr., and Walter P. Chrysler.

These men agreed that, because of his experience in developing new products and his known capabilities in that area, Charlie Kettering was the best man in the nation to head up such an organization. They knew Kettering as vice president and chief technical man of the Dayton Engineering Laboratories Company (Delco). As a unit of United Motors Corporation, Delco had become a part of General Motors in 1918.

Sloan in particular, as the man who was destined soon to become the architect of the General Motors of the present day, recognized Kettering as just the kind of man needed to help build it. In 1916 Sloan had helped Durant organize United Motors Corporation, with Delco as one of its units. He had been named president of that amalgamation of automobile parts makers, and so had been associated with Kettering ever since that time.

Those General Motors men knew that, besides the important advances Kettering had made at The National Cash Register Company during his five years there, he had made to the automobile two contributions of outstanding importance. He had invented a new and dependable system of battery ignition; and, by developing the electric self-starter, he had done away with the hand starting crank—that troublesome and dangerous device which Henry M. Leland had called "the unruly, vicious, and turbulent starting crank."

By eliminating the hand crank, the self-starter had been an extremely important factor in extending the usefulness, and in expanding the use of the automobile. For one thing, it had made it possible for women to become automobile drivers. Speaking once to a gathering of young women, Malcolm Bingay, friend of Kettering's and long-time Detroit newspaper editor, said that in developing the self-starter Kettering "did more to emancipate women than Susan B. Anthony or Mrs. Pankhurst or all the other valiant gals who get the credit he deserves."

When those General Motors men chose Kettering, they knew also that he had meanwhile developed Delco-Light, the system of engine and storage batteries of which many thousands were then being made each year and which was bringing the boon of electric light and power to the farm. That was well before the time when high lines from central power stations had been run out into the country. The men knew, too, that during the First World War, then not long past, he had done important things, including the development of a self-guided and manless bombing plane, called "The Bug," which was the predecessor of the guided missile of the present day.

Kettering was therefore invited to organize and direct a central research staff for General Motors with the aim of keeping the concern in the forefront of progress. After some hesitation on his part, for he was quite happy where he was, and after making some stipulations regarding the freedom he must have in undertaking and pursuing new endeavors, he accepted the invitation. With that freedom in mind, one of his stipulations was that he should "have no responsibility and no authority . . . I don't think you can run a research laboratory any other way," he said. "The minute you take responsibility or authority, you quit researching." He said, too, that you can't keep books on research, because you don't know when you are going to get anything out of it or what it is going to be worth if you do get it.

In that year of 1919 General Motors was a concern doing a business which in dollar volume was only a fraction of what it is now. The manyfold increase in the years since has been due in no small part to the activities of the research staff which in his new capacity Kettering organized and guided during the 27 years following. The contributions to General Motors which Kettering thus made were both tangible and intangible in character.

The tangible things were the new products he originated and of which he directed the development, as well as the many improvements made in products already in existence. He originated and guided the development of knock-free gasoline and of the high compression automobile engine to use it to best advantage; of better and longer lasting finishes for cars; of air cooling for the domestic refrigerator; of the non-toxic and non-inflammable refrigerant, "Freon"; and of many other things, including the improved Diesel engine which, in just one of its many applications, has revolutionized the powering of railroads. Through his efforts, distressing and destructive vibration, so universal in the automobile engines of that early time, was corrected; bearings, axle gears, and springs were made better and longer lasting; intake and exhaust noises were silenced; brakes and lighting systems were refined; and lubricants and lubrication systems were greatly improved. These and the many, many other advances which came out of Kettering's devoted efforts were all aimed at making the automobile easier to drive, more pleasant to ride in, more trouble-free, and more economical. And, to the great benefit of those who drive automobiles, his efforts were eminently successful.

On the intangible side, a compact appraisal of Kettering's efforts in General Motors was once given by Alfred P. Sloan, Jr., in these words:

"I would say that the intangible side of it, if it could be evaluated, has meant more to all of us than all the tangible things, important as they are. He has been an inspiration to me and to the whole organization, particularly in directing our thoughts and our imagination and our activities toward doing a better job technically and the tremendous importance of technological progress . . . Also, his courage, his tenacity, his belief in the soundness of his deductions and his work have been essential, because nobody knows better than you the terrible resistance you get in trying to do something different."

But Kettering's influence as an apostle of progress extended much further than General Motors. During his career, and especially during the first half of it, research as an indispensable aid to industrial progress was far from having been as well accepted as it is today. In his conversations with businessmen everywhere and in his frequent addresses before gatherings of such men and others, Kettering kept saying:

"I am not pleading with you to make changes. I am telling you you have got to make them—not because I say so, but because old Father Time will take care of you if you don't change . . . Consequently, you need a procurement department for new ideas.

"We think of elections as being held in the spring and the fall," he said too. "That is not what has made this country great. It is the elections that are held every day and every hour in every community in this country, in the stores . . . where people shop. They are voting . . . It is that election, that continual election of preference, which is the reason why we have to improve."

In Kettering's view, the most important thing in industrial research is picking the problems to work on. And to that matter he gave his best thought. Thus, the incentive for the research on automobile finishes which he instigated, and which was a major project during his early years with General Motors, was greater than the need for a finish more durable than paint. With the swing to closed bodies, a faster drying finish than old-fashioned paint was urgently needed. Two weeks or more were required to finish an automobile body. And, when some thousands of bodies were being built each day, the paint shop to contain all of them during the long finishing process was becoming excessive in size and cost.

To the paint suppliers Kettering said that the way automobiles were then being painted was all wrong. "It is taking much too long to do the job and you are putting the same kind of paint on automobile bodies as on pianos. You know what would happen if you set your piano out in the back yard and let it get rained on and let the sun beat down on it while still wet. The neighbors would take you to the insane asylum. Why can't we get paints for our cars that will stand up better and that can be put on quicker?"

In answer, those men said they thought that it might be possible to cut a day or two off the two weeks needed then to finish a car.

"That is not nearly good enough," said Kettering.

"How long," they asked him, "do you think it ought to take to paint a car?"

With characteristic daring, Kettering replied, "About an hour."

"Why, we couldn't put on one coat in an hour!" exclaimed the paint men.

"Why not?"

"Because the paint wouldn't dry."

"There, that's the key to your problem," said Kettering. "Can't you do something to make it dry faster?"

"No, we can't do that because nature fixes the time of drying."

Nevertheless, after some years of experimentation on the part of men in Kettering's laboratory who worked on problems of application and on tests of durability, and of men in the Du Pont Company who worked on composition, a synthetic finish that was at once fast-drying and much more durable than old-fashioned paint was developed. That important advance made the finishing of an automobile body an assembly-line process. The simplification in procedure and the large reduction in floor space required effected a big saving in the cost of making cars. Commenting on this notable development, one of the body-building Fisher Brothers said—although, to be sure, with a little exaggeration—"If these synthetic coatings had not come along when they did, it would have been necessary to put a roof over the entire state of Michigan to get storage space great enough to take care of the drying and finishing of automobile bodies."

An important aspect of the improvements in which Kettering had a part and of the new products developed under his guidance is that the principal beneficiary of them is not the concern which paid the cost of his efforts but the people of the nation. Thus the search which he initiated for means of boosting the octane number of gasoline and for building the high compression engines to use it to best advantage has resulted in such a gain in economy that two gallons of gasoline now do as much work as three gallons used to do. Fourteen billion dollars a year is what people are paying for the gasoline they buy today. Had it not been for the advances which came out of those efforts, the three gallons of gasoline we would have to be buying instead of the two we do buy would cost us five billion dollars a year more than we are paying. That by itself amounts to a saving on the average of thirty dollars a year for each person in the nation.

Pierre S. du Pont, appraising Kettering's research endeavors, said that his development of tetraethyl lead as an antiknock agent, an early and important advance on the road to knock-free gasolines, was one of his greatest contributions—this because it came so altogether out of nothing but his imagination. However, that advance, first sold to the public as "Ethyl" gasoline in 1923, was only one of the several steps in Kettering's long effort to batter down the barrier of knock which was limiting the output and the economy of the automobile engine. He had begun that endeavor even before he took up his work with General Motors, and he carried it on continuously until the time of his retirement in 1947. That effort was, as Kettering often said, a typical instance of the laborious and sometimes heartbreaking process by which advances have to be made.

Besides the host of technical problems that had to be solved along the way—some of which seemed impossible of solution—he had to keep continually selling the idea, for few there were who believed that his optimistic goal was attainable. Many oil men kept telling him that making much increase in the octane number of gasoline was not practical; and, even if it were, the cost would be too high to make it worth while, they said.

"But you can't stop the rise in octane number until nature stops it for you," Kettering would say. "Here is one of the greatest steps in the world, wide open like a prairie. It remains only to find out how to do it."

On the side of the automobile, also, most engineers thought that further increases in engine compression beyond that of the time were not feasible. To them Kettering would say, "To get high engine efficiencies, explosion pressures have to be high. There is no other way . . . If you can get high economy with low explosion pressures, write me a letter about it. I would like to know how it is done."

To convince doubting automobile and petroleum engineers that his ideas for engines of really high compressions were practical, Kettering built some with double the compression of the time. He demonstrated thereby that, with proper design and with gasoline of the needed octane number, such engines would run with all the softness and smoothness to which we have become accustomed.

It is Kettering's philosophy that to sell anything, and especially the advanced products of research, you have to have a sample. "I have no patience," he said, "with the fellow who says, 'I have been telling them for years and they don't pay any attention to me.' All he has done is to talk to them."

Slowly, under the impact of Kettering's persistent campaigning, his views gained acceptance. The men in the oil industry, through brilliant researches of their own, have learned that the barriers to better gasolines which seemed so impassable can be broken down. Already, through newly developed and marvelous refining methods, and with the supplementary aid of tetraethyl lead, refiners are making automobile gasolines of nearly 100 octane number, whereas when Kettering began his efforts gasoline was only about 50 octane. Meanwhile, those men of the oil industry came to think so highly of Kettering's long and zealous efforts toward such improvement that in 1948 the American Petroleum Institute chose him as the recipient of its highest award, the API Gold Medal for Distinguished Achievement.

To take advantage of the improved gasolines, automobile engineers have meanwhile been raising engine compression year by year, until now it is at a level more than twice what it was when Kettering's efforts at improvement began. In this they have been aided by knock-reducing improvements in engines, called mechanical octane numbers, which in recent years they have learned how to make.

When in the late 1920's Kettering began his effort to make the Diesel engine more useful in the field of transportation, it was already 35 years old, having been invented in 1892. But it suffered then from a number of shortcomings, one of which was excessive size and weight. One by one, through painstaking experimentation, those difficulties were overcome. "The weight of the Diesel engine was in somebody's head," said Kettering. "Diesel engines do not have to be heavy. We always want to blame our ignorance on the engine. It's like the doctors with their incurable diseases. Did you ever stop to think what an incurable disease is? It is one the doctor doesn't know how to cure."

After some years of intensive experimental effort, Kettering and his associates came up with a new and improved type of Diesel engine. It was only a fraction of the size and weight of other Diesels of comparable power, it was easy to control, and it would run a long time without attention. Within a few years that improved Diesel engine had revolutionized the powering of railroads by displacing almost completely the century-old steam locomotive. For the Navy that new Diesel powered the first submarines that were able to keep up with the fleet and to maneuver with it. It came to be used extensively also in many other types of marine craft. It is used in buses and trucks on the highway. It is used in the oil fields and in pipeline pumping stations. It is used in tractors, road machinery, construction equipment, industrial power plants, and many other places.

Something of what the improved Diesel engine has done for the railroads was related in 1955 by James M. Symes, president of the Pennsylvania Railroad.

"The greatest single contribution to the economic and efficient operation of our railroads during my 40 years of association with the industry has been the development of the Diesel locomotive," said Symes. "We all know the important part General Motors has played in that development . . . I would guess that this development alone is saving the railroads a minimum of 500 million dollars a year."

An intimation of why Kettering has been able to do so many creative things is contained in this evaluation of him by the great scientist, Robert A. Millikan. Kettering is unique, said Millikan, in that "he combines in one individual the interest in pure science with the practical ability to apply knowledge in useful devices." But, from Kettering's practical viewpoint, "Engineering must partake as much of economic horse sense as it does of scientific principles."

Kettering is opposed to the standardization of anything that can be improved. "I have no objection to standardizing bolts and nuts and screws," he said once, "but I do have a terrible obsession against the standardization of ideas."

Important among Kettering's intangible contributions to people are his uncommon optimism about the future and his constant effort to inspire that same outlook in others. Even in the depression years of the 1930's he continually preached the need for revitalizing change in industry. Through his frequent addresses and through articles in magazines and elsewhere, he kept saying, "We have a great many people who are talking about dividing up what we have. We don't want to study division. We want to study multiplication. Give research a chance in this country and it will start the wheels."

Summing up his view on what lies ahead, Kettering has said: "The opportunities of man are only limited by his imagination. But so few have imagination that there are 10,000 fiddlers to one composer . . . I think anybody can write the most fantastic thing about the future of this country of ours and it will be too little in the end."

The Importance of Experience

The following anecdote from a recent address by C. F. Kettering illustrates his faith in the kind of knowledge acquired through actual practice rather than from pure theory or formulae alone:

★ ★ ★

During the early part of the war, we were building some sub-chasers at the works at Bay City, Michigan. They were going to launch the first test boat on a Sunday. The boat was sitting up there on the river bank, and I was talking about it with an old tugboat captain I knew very well. "Joe," I said, "those propellers are too big."

He looked over at them and said, "Boss, they always make them too big."

"Well," I said, "if you were changing them, what would you do?"

"I'd cut 7 inches off," he said.

So I went to the naval architects and told them that we had recalculated the propellers and found that they had made a serious error. In about an hour, I got a telephone message.

"You have no one up there who can calculate propellers," they said.

"You'd be surprised," I replied.

In another hour, they called back.

"How much do you think they're off?" they wanted to know.

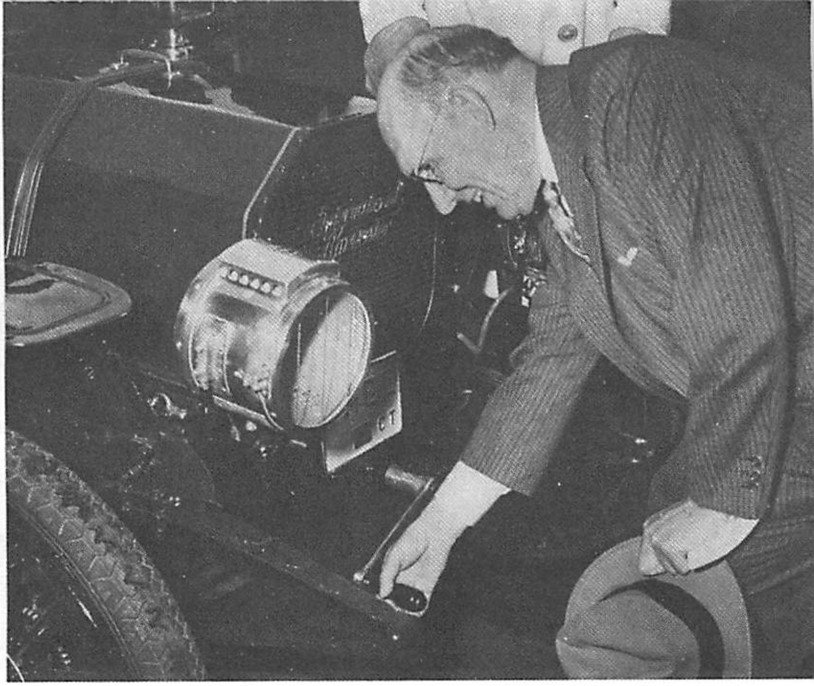
"About 7 inches," I answered.

"Well," they replied, "there was an error in those calculations. But it wasn't 7 inches . . . it was only 6½ inches. The thing that worries us is how you found it out. No one in our institution understands how you could possibly find it out."

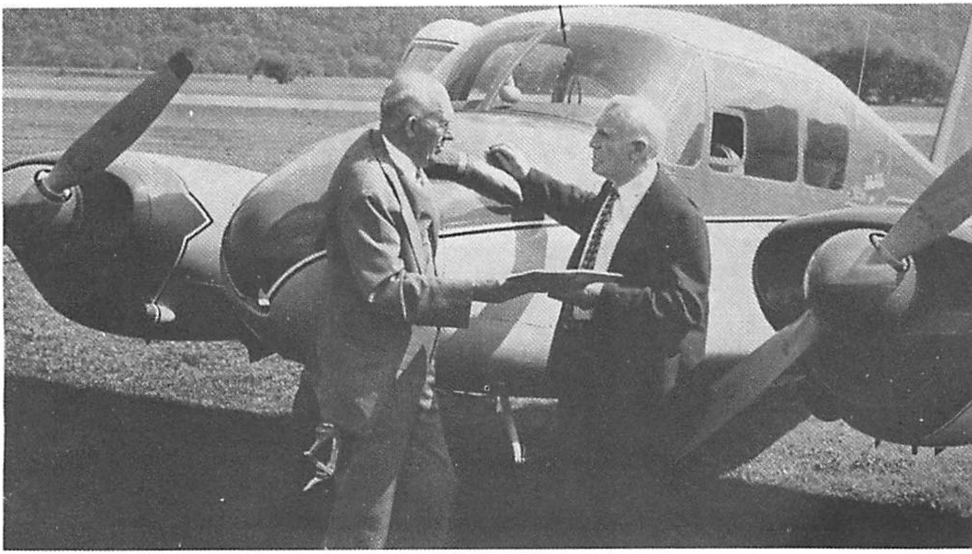
"Well, I assure you we found it out," I said. Then I told him that Joe and I had sat down on a tie-pile and discussed the propellers.

"There is a fellow who has looked at propellers all his life and he didn't do any calculating," I said. "He didn't know anything . . . they were just too big to him."

Now you don't want to wash that out. There are fellows who have had experience and it is amazing how good they are sometimes.



Kettering spins an old car's crank, an operation he eliminated for the motorist. Scene was Dayton during Oil Progress Week in 1949.



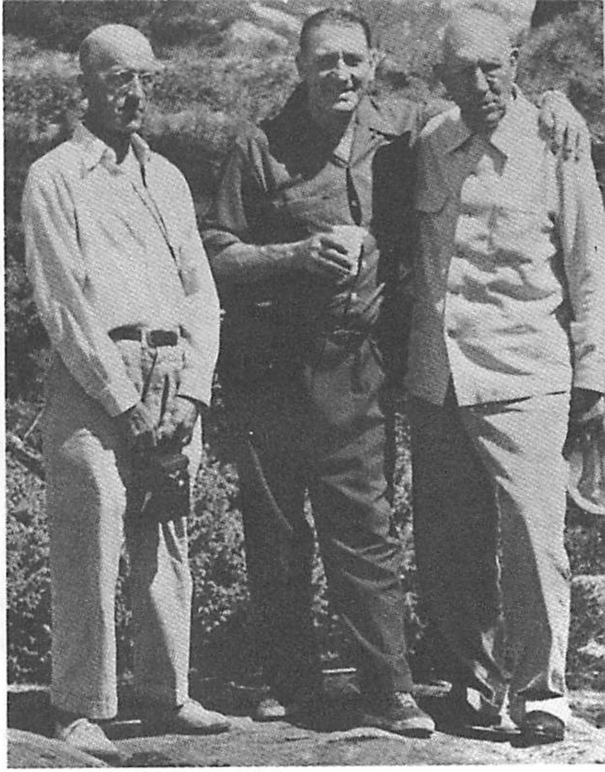
Discussing the merits of his new Piper Apache with an expert on the subject, William T. Piper, Sr. Place was Lock Haven, Pa.; year was 1954.

Donning a parachute at Maxwell Air Force Base, Alabama, prior to a flight.

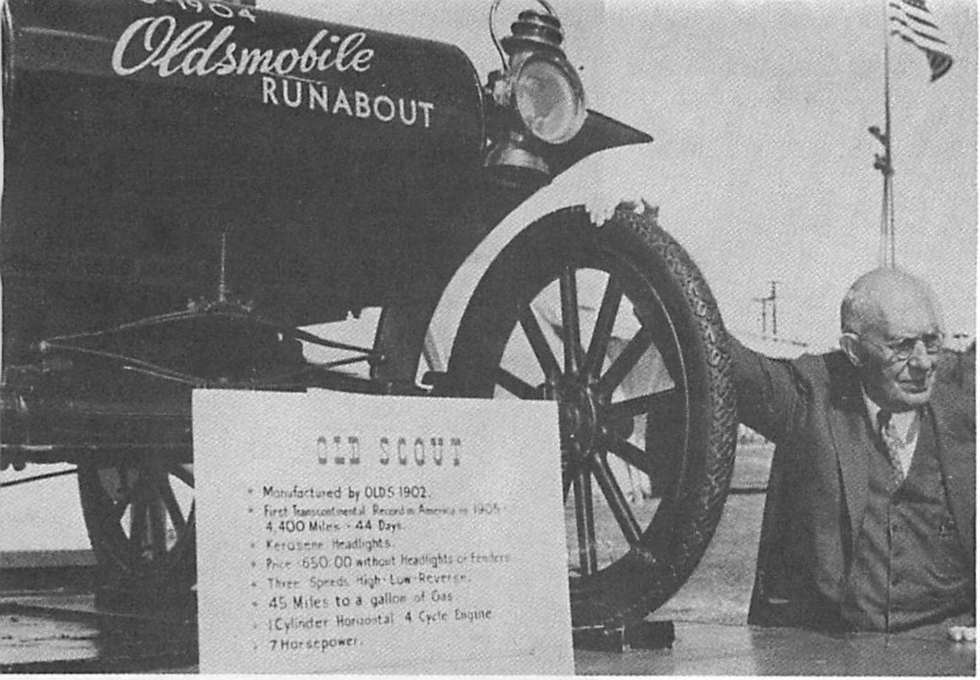
Relaxing at Muroc Dry Lake, California, during tests of the World War II "Bug."

Kettering uses the nose of an airplane as a desk while filling an autograph request.

With O. Lee Harrison, left, and "Reg" Stansbury at Okeechobee Lodge, in the summer of 1955.



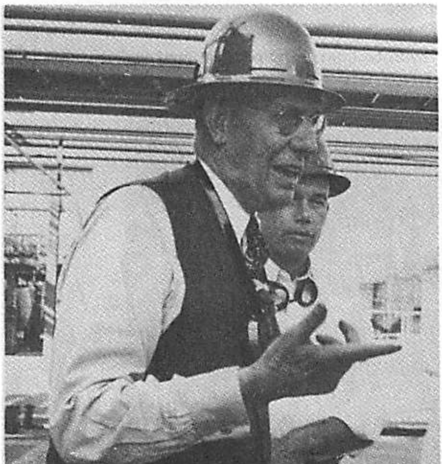
Showing high-compression engine to R. E. Wilson at French Lick, Ind.



"The Boss" poses with the famous "curved-dash" Oldsmobile of 1902, which set a record by traveling 4,400 miles in 44 days.

With Alfred P. Sloan, Jr., left, and Colonel E. A. Deeds on "Boss Ket's" 75th birthday.

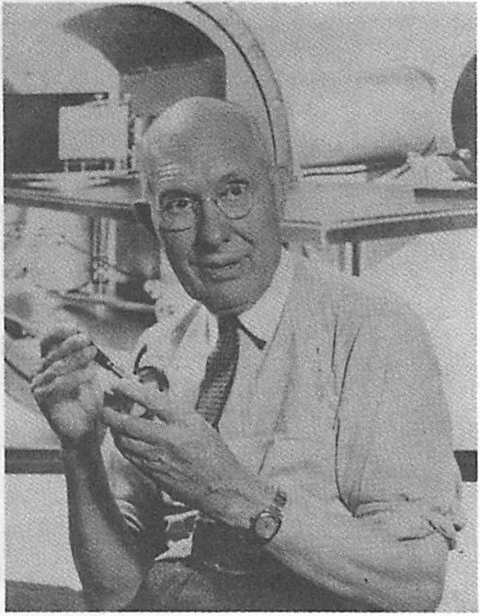
Charles F. Kettering points out a device on the firs
Diesel locomotive delivered to the Baltimore & Ohio



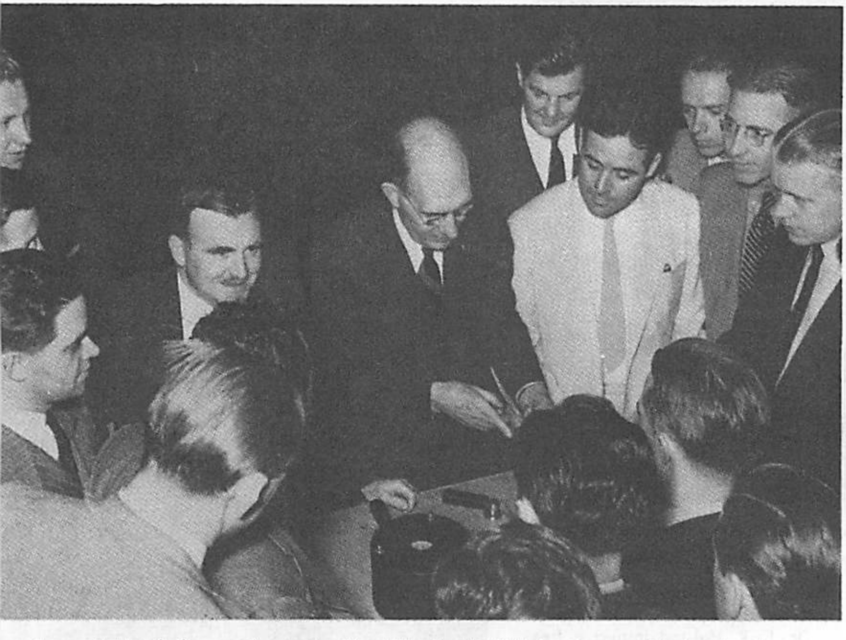
"The Boss," caught by the camera while wearing an unusual hat.

Kettering, Harlow H. Curtice and Dr. L. R. Hafstad inspect a free-piston engine in futuristic car.

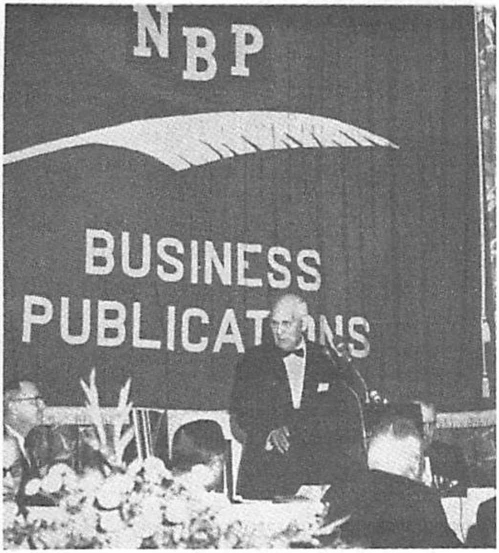
Kettering enjoying a preparedness parade held in Dayton during World War II.



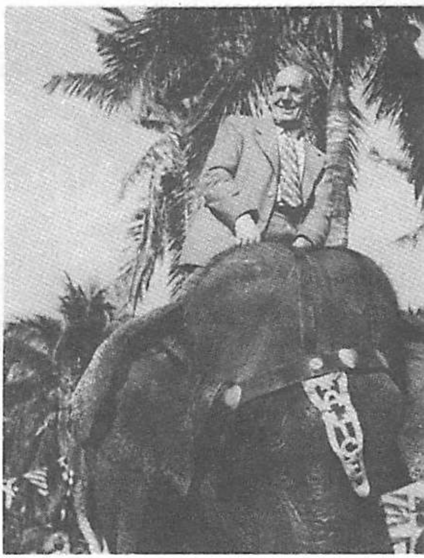
Shown with specialized instrument for analyzing hydrocarbons. Photograph was taken in 1947.



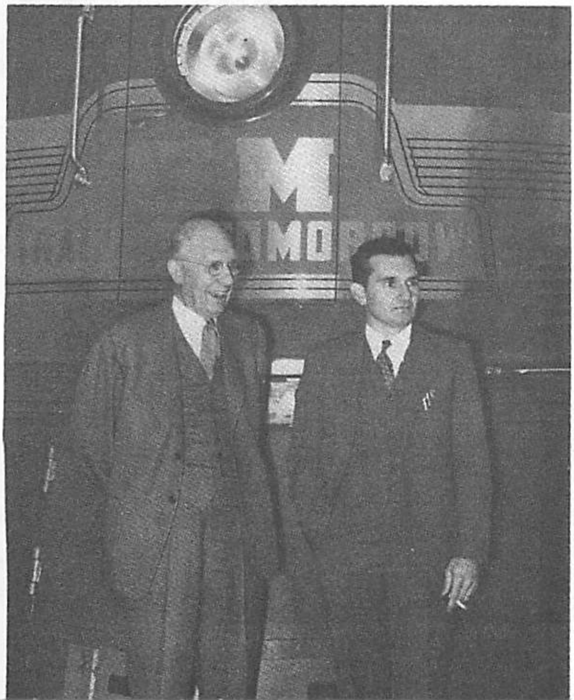
Demonstration before servicemen typifies "The Boss'" flair for showmanship in education.



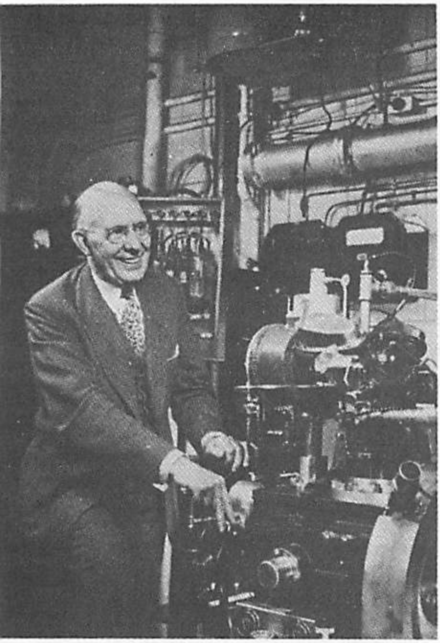
As a speaker Kettering has entertained countless thousands. He is shown here at an award dinner.

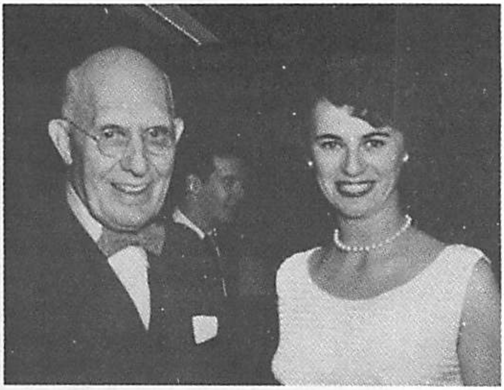


In a drawing room or riding an elephant, Ket has capacity for fun.



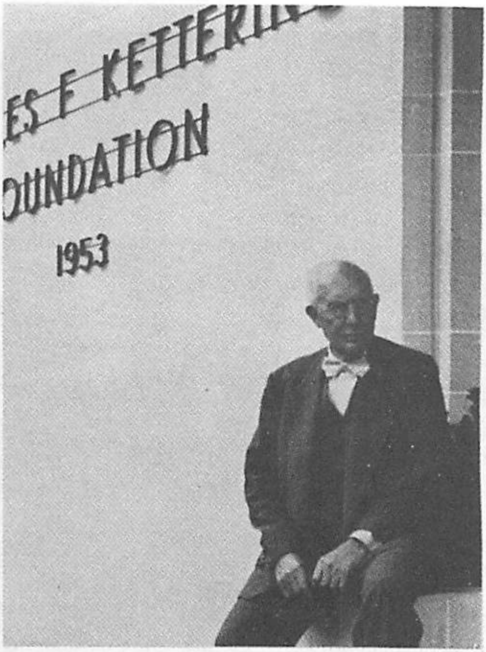
Kettering and his son, Eugene, in front of GM's Train of Tomorrow.





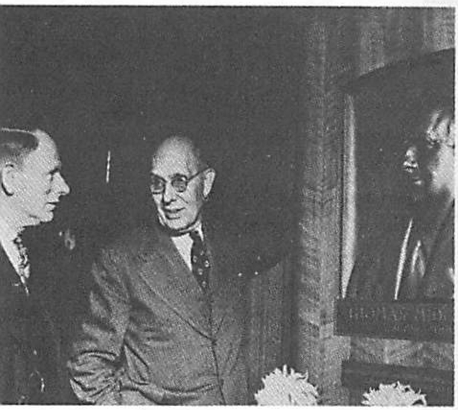
With Antioch student during dedication dance at new Foundation Building.

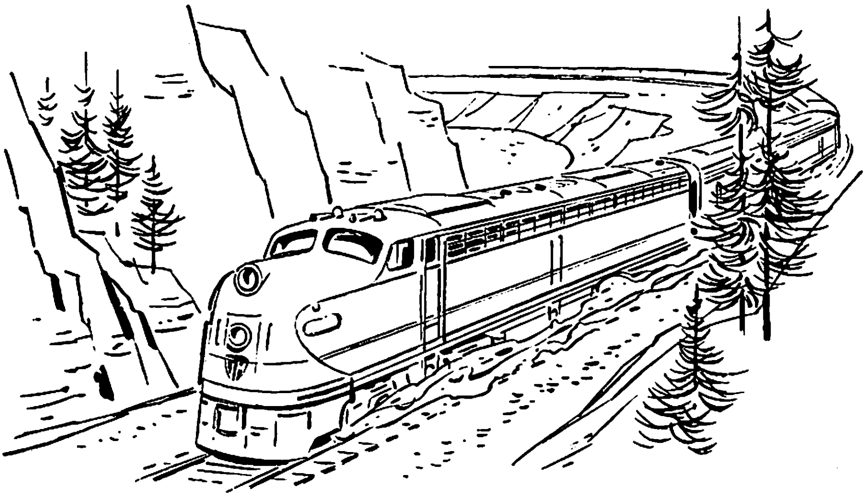
Kettering shown with a special test engine in one of GM's laboratories.



At the entrance to the Kettering Foundation Building in Yellow Springs.

T. A. Boyd and Ket discuss plaque honoring Thomas Midgley.





At a crucial moment in American railroading history the Diesel locomotive made its debut. Behind that event lies the unusual story of a temperamental yacht engine and the curiosity of C. F. Kettering as to why the Diesel was not as good as it should have been.

Working on the Railroad

IT IS A strange paradox that the Diesel engine, the most efficient power plant ever devised, remained for almost 40 years the neglected stepchild of the industrial world. As late as 1930 a popular magazine after an exhaustive study found the Diesel "only fair." The Diesel, it said, was about as exciting "as a weekend visit with your maiden aunt."

Only four years later, however, the same publication took another look at the Diesel. "The entire (Diesel) industry is seething and boiling with ideas," it found. "He who undertakes to belittle it does so at his own risk."

What happened between the appearance of these two conflicting articles constitutes one of the ironic technological stories of modern times. It is a story whose plot was shaped in large part by C. F. Kettering. It was to carry massive implications for industry in general, and for American railroading it brought a revolution in operating procedures and salvation from financial woes.

What Kettering did, more than any other man, was to rescue the Diesel from semi-oblivion by the simple expedient of bringing a fresh viewpoint to its design and manufacture. Incredible as it seems in retrospect, such an approach had never been seriously tried since Dr. Rudolph Diesel had nearly blown himself to eternity while testing his first engine in 1892.

Diesel believed in his ignition-by-compression engine with the zeal of a crusader. In 1912, shunning modesty, he told the American Society of Mechanical engineers, "The Diesel engine has doubled the resources of mankind as regards power production . . . nowhere in the world are the possibilities for this prime mover as great as in this country."

Whether Diesel would have been capable of bringing his engine to its full potentialities will never be known. On the eve of World War I he disappeared mysteriously from a ship crossing the English channel.

Following his death, the Diesel engine gained acceptance slowly and only for limited use. Fifteen years later Diesels were still heavy and cumbersome. They performed and even looked like steam engines. Although thousands were used on large ships or in stationary power plants, the Diesel rarely qualified for any sort of mobile application.

Kettering, like every other engineer, knew that theoretically the Diesel had staggering possibilities. It could turn into useful work several times more of the energy in a given amount of fuel than could the steam engine. It was even more efficient than the gasoline engine.

During the 1920's Kettering studied what he termed "the enormous gap between Diesel theory and Diesel practice." From these studies he concluded that a first-rate Diesel had yet to be made, that engineers had relied too much on Diesel textbooks and too little on original research and experimentation.

His hypothesis was as unorthodox as it was original: A Diesel engine did not necessarily have to weigh a single ounce more than a gasoline engine. The trouble with the Diesel was that it had got started in the wrong direction in the beginning; that is, it had been designed more according to steam-engine methods than to internal combustion methods.

"The practice soon became standardized until finally it became almost a dangerous thing to make a Diesel engine lighter," he said later.

Kettering set about to destroy some of the fetishes surrounding Diesel design in a close-to-home way. He bought a Diesel-powered yacht, the "Olive K," but spent little time on deck. In the hot, oily engine room he tinkered and experimented with its temperamental Winton engines.

Unlike a gasoline engine, the Diesel's fuel is injected directly into the cylinder instead of being mixed with air beforehand in a carburetor. Kettering's yacht experiences quickly confirmed his long-held belief that one of the chief bottlenecks holding back the Diesel was its fuel-injection mechanism. Out of his engine-room tinkering came several ideas for a new fuel-injection system consisting of separate, self-contained units for each cylinder, thereby eliminating complicated plumbing and resulting pressure variations.

Kettering took these ideas to the Winton people. Would they manufacture two Diesels for use on a successor to the "Olive K" incorporating some type of new fuel-injection system? They would and did. Without knowing it at the time, the inventor-turned-yachtman was on the way to revolutionizing the motive power of the American railroads. The new engines which he ordered were to be the forerunners of the Diesels which today have made American railroads the most efficient in the world.

Meanwhile, "The Boss" turned loose a group of his aides in the General Motors research laboratories. Their job was to separate textbook "propaganda" about Diesels from the truth. Kettering's method of climbing out of the intellectual rut that had stymied Diesel development was to start from the beginning. Using simple, single-cylinder test engines the researchers began the long job of sifting facts from fancy.

One fact regarding Dr. Diesel's invention appeared almost insurmountable. Because of the complexities of its fuel-injection system, every Diesel every built was fantastically slow. Five-hundred revolutions a minute was approximately the Diesel's limit, hence its power output was low.

To remove this impediment to broader Diesel use, Kettering offered a simple yet bold suggestion. Instead of operating the Diesel four-cycle, like an automobile engine, perhaps the two-cycle principle used in outboard motors should be tried. In a four-cycle, one-cylinder engine there is only one power stroke for every two revolutions; whereas the two-cycle engine fires once for each revolution. Thus, a two-cycle Diesel would deliver exactly twice as many power strokes running at a given speed as would a four-cycle design. Without increasing weight, power theoretically would be doubled—that is, if a practical, lightweight two-cycle Diesel could be designed and built.

Kettering believed it could. His opinion was shared by Alfred P. Sloan, Jr., then president of General Motors, who had long been interested in the Diesel and its still-unrealized potential. By 1930 General Motors' management felt that the corporation's Diesel studies had progressed to a point where it would be advisable to acquire manufacturing facilities. That year negotiations were completed to buy the Winton Company, the same firm which had made the Diesels purchased by Kettering for his yacht.

In one of these curious coincidences that occasionally shape industrial history, the Electro-Motive Company of Cleveland, pioneer developer of gasoline-electric railway cars, was at that moment in serious straits. Fighting againt tremendous odds, a small group of men led by a former motor-truck salesman and locomotive engineer, H. L. Hamilton, had built in less than 10 years a sizeable business in gasoline-electric "doodlebugs" for railway branch lines and other light operations.

With the onset of the 1929 depression, however, Electro-Motive's sales had dropped to an alarming level. Railroads were cutting down on branch-line service. Purchases of light equipment were dwindling. The future of the infant company depended upon acquiring some kind of internal-combustion engine that would deliver more power at less cost than a conventional gasoline engine. If this search ended in failure the company was finished.

Thus, Electro-Motive had begun to eye the Diesel wistfully about the same time Kettering was experimenting with the engines on the "Olive K." It was Electro-Motive which had developed the unit fuel injector installed on Kettering's second set of yacht engines. But despite the eventual satisfactory performance of the injector, Electro-Motive still lacked the kind of Diesel it required, depending on Winton for its actual engine manufacture.

The course to be followed was clear. By purchasing Winton, General Motors could accelerate its own Diesel program, and since Electro-Motive was Winton's main customer it was logical to acquire the railway-car manufacturer as well. Both Winton and Electro-Motive in turn lacked the capital and research facilities necessary in the forthcoming effort to modernize Rudolph Diesel's engine. Thus, the acquisition of Winton and Electro-Motive set the stage for what was to result in a completely new transportation industry.

That same year, Kettering's son, Eugene, came to Cleveland to join the engineering group that had plunged into the problem of devising a better fuel-injection system. Commenting on the magnitude of the task that faced them, Eugene Kettering said years later, "I was a very green kid just out of school but it was not long before I found I knew about as much as anybody there did about two-cycle engines and unit injectors."

Clearly the small research group had entered completely uncharted territory. Meanwhile in Detroit "The Boss" and his team were using single-cylinder, guinea-pig engines to drive the bugs out of two-cycle Diesel operation. Millions of dollars and many months of hard work were to be spent before even partial success was achieved. The challenging project had entered its "shirt-losing" stage, a period that was to last for several years.

By 1933, the year of the Chicago Century of Progress, the Diesel researchers had a pair of eight-cylinder, two-cycle engines to show for their efforts. They were radically different from any Diesels of the past. Weight per horsepower had been cut to 20 pounds, an unheard-of figure, and many other startling innovations were incorporated in their design and manufacture. With its flair for showmanship, General Motors decided to unveil the unique engines at the Fair, where they were to provide part of the power for the Chevrolet exhibit. It was a bold move which later had important repercussions for American railroading.

The railroad industry had weathered many crises, but the Depression of 1929 had brought the darkest days of all. By 1933 passenger miles had dropped to a third of the 1920 level; revenues had declined a billion dollars in the same period. Many roads were already in receivership and others were facing the same fate. It was a time for drastic steps, and Ralph Budd, president of the Burlington Road, was prepared to take them.

Budd was convinced that the railroads could win back part of their lost passenger business if they offered fast, low-cost service by means of streamlined, lightweight trains. He was seeking the dramatic in transportation, the same forward-looking spirit which the forthcoming World's Fair was to symbolize. He knew, however, that operating costs must be pared to the bone. Perhaps a Diesel could best power the special lightweight streamliner being built under his direction.

Hearing about the planned GM Diesel display, Budd went straight to Kettering in Detroit. He wondered if General Motors would sell him such an engine for the soon-to-be-completed "Pioneer Zephyr."

"We wouldn't dare sell you this thing," Kettering said. "We don't even know if it will run."

Budd was not easily discouraged, however. He accepted Kettering's invitation to take a look at the experimental engines as soon as they were installed at the Fair. The engines ran, of course, but Budd knew they had the benefit of a crew of experts in constant attendance. Rough and tough railroad service was something else again.

Despite these misgivings Budd decided he wanted a similar engine to power his precedent-shattering train. As he later explained, "Actually, I wasn't taking any chance at all. I knew that if General Motors was willing to put the engine in a train, the national spotlight would be on the Corporation. They'd simply have to stay with it until it was satisfactory."

On May 26, 1934, the world's first Diesel-powered streamliner successfully completed an historic nonstop run from Denver to Chicago to open officially the Century of Progress' second year. Crowds lined the route from start to finish to cheer the train on. Seldom in transportation history had a single development so captured the public imagination. Gripped by the worst depression in history, the nation viewed the Diesel-powered "Pioneer Zephyr" and the Union Pacific's earlier gasoline-powered streamliner as forerunners of a new and better era. An age of modern rail transportation was beginning. Even the public knew it.

Earlier that year Kettering had met with top Electro-Motive officials in a Washington hotel room. Electro-Motive already was anxious to challenge steam, the supreme form of railroad power for a century. Hamilton and his lieutenants visualized a new kind of Diesel railroad locomotive which could take on traditional steam locomotive jobs, not just haul lightweight passenger streamliners.

After hearing the plans for the new locomotive, Kettering agreed with their soundness. "Why don't you make one?" he asked. Told that several hundred thousand dollars would be required, Kettering said he thought approval of the project could be obtained. When he presented the proposal to General Motors' management, he was asked whether a locomotive unlike any ever built before could be developed for several hundred thousand dollars.

"Probably not," Kettering replied, "but I figure if we spend that much we'll come through with the rest."

From the old-line steam locomotive manufacturers came grumblings and warnings to railroad men. Not long before, one locomotive company had said in a trade-paper ad:

"Come what may — extremely lightweight trains, very high speeds, streamlining or what not — steam designs are ready to meet every demand of our railroads with the least amount of experimentation." It added that steam would remain "the dominating power for railroad transportation for a long, long time to come."

In actual fact, steam as a railroad motive power was already doomed but its death rattle would not be heard yet for several years.

Kettering was not bothered by the barbs of steam advocates. He told a worried associate, "Suppose our competitors do think we're crazy. As long as they believe that, we'll have just that much more time to develop a really good locomotive."

Meanwhile the more-powerful Diesel engine that Kettering envisioned was beginning to emerge from a dream into reality. If Kettering's methods were unorthodox, they nevertheless seemed to be working. When a friend asked "The Boss" some years later how he came to design "such a screwy engine," Kettering replied:

"We didn't design that engine. We simply made a single-cylinder engine and we gave it some pistons to try out, and it told us which of the pistons it liked the best; then we gave it some camshafts and it selected the type it liked best; and after it had made its choice of all the various parts and had developed itself, so to speak, we simply accepted the engine's judgment as the basis for our design.

"Nobody told the engine what it ought to be—we recognized that the engine knew more about how it ought to be built than any designer sitting in an office with a slide rule."

While this work was progressing, bulldozers had moved into a former corn field at LaGrange, Illinois, to build the world's first factory devoted exclusively to the manufacture of Diesel locomotives. In the more than 20 years since then, the building contractor has never left the premises. Even the most avid advocate of the Diesel locomotive could hardly have foreseen the growth that was in store for the once-struggling Electro-Motive organization.

The "Pioneer Zephyr" and other lightweight trains during the factory erection at LaGrange were setting the railroad world on fire. The Union Pacific's second streamliner, for example, was powered with a Diesel instead of gasoline engine. Late in 1934 it left Los Angeles for Chicago in an all-out attempt to break a 29-year-old speed record set when the fabulous "Death Valley Scotty" had chartered a special train for a trip east. With the use of 19 different steam engines en route, "Death Valley Scotty" had reached Chicago in a little under 45 hours. The Union Pacific Diesel covered the same route in six hours less time, or 20 hours under the normal schedule. A veteran porter on the train was so awed by the performance that he was found listening to the click of the wheels as the Diesel high-balled along. "I've heard some fast clickin'," he said, "but I never heard a sound like that befo'." And when a steam locomotive nicknamed "Big Alice, the Goon" attempted to maintain the schedule which had been set by a Diesel-powered "Zephyr," she practically collapsed in the attempt. "We almost made the time," a railroad man said, "but Alice didn't stop trembling for two hours after we got her into the roundhouse stall."

The first locomotive to emerge from the new Electro - Motive plant was a 600-horsepower switcher completed in May of 1936. Lacking champagne, Electro - Motive officials broke a bottle of ginger ale over its nose to launch the beginning of a long line of Electro-Motive Diesel-electrics.

By this time the hard - to - believe records being piled up by the new Diesel passenger streamliners had put General Motors, Winton and Electro-Motive squarely on the spot. It became apparent that the railroads —lukewarm to the Diesel at first— were now prepared to run the wheels off them. It was good news, but it placed Electro-Motive in the position of a ballplayer who is expected to hit a home run every time he steps to the plate.

To make sure that its batting averrage would remain high, Electro-Motive in the summer of 1936 assigned Eugene Kettering to begin development of a new series of Diesel engines incorporating all the improvements that previous experience suggested. This far-reaching project was the basis for the subsequent complete Dieselization of American railroads.

Late in 1938 the first LaGrange Diesels with the new engines were delivered for passenger service. Thereafter, milestone followed milestone with dazzling and sometimes confusing frequency. Late in 1939 the world's first Diesel freight locomotive — dark green with a bright yellow stripe down its side — rolled from the busy paint shop at LaGrange.

Once again Electro - Motive engineers were apprehensive. They told the railroads, in effect, "We don't know exactly what he have here, but we'd like you to help us find out." The railroads accepted the offer and the "103" was promptly put through paces which would have made its designers shudder. They needn't have been worried. During the next 11 months the "103" proved itself the master of any steam locomotive ever built. Engineers unfamiliar with its power broke drawbars all over the country. Most amazing of all, the new Diesel freight performed its near miracles at less than half the operating cost of steam.

Engineers were reminded of "Boss Ket's" reply to a railroad man who doubted the pulling power of a Diesel for heavy freight duty. "Just how much will she pull, Mr. Kettering," the railroader asked.

"I really don't know," Kettering replied. "But I'll tell you this. The Diesel can pull a railroad right out of bankruptcy."

By 1940 the railroads were clamoring for the new locomotives. During the next 15 years Diesels took over approximately 85 per cent of all the freight, passenger and switching operations in the most far-reaching change in the history of the industry. The neglected stepchild of motive power had almost overnight emerged as an industrial Marilyn Monroe.

The Diesel's appeal was irresistible: It included the ability to make faster times; up to 50 per cent savings in operating and maintenance costs; less "down" time for maintenance and repair; the elimination of ash dumping, boiler washing and other non-productive work; a cleaner, softer ride and less wear on costly track; uniform dependability in all types of weather and over all kinds of terrain.

The demise of steam removed a colorful facet of American railroading. The huge, spinning drivers of the steam locomotive, its flashing valve gear and shrill whistle have for the most part disappeared, to be replaced by the brightly painted, sleek Diesels that today furnish the railroads' muscles. The passing of steam, however, was as inevitable as the decline of the Clipper Ship. In the battle of the power giants, the Diesel had proved invincible as far as railroad needs were concerned.

Kettering's dissatisfaction with what had been accomplished with the Diesel engine led to the opening of other industrial frontiers as well. During World War II, the two-cycle Diesel was to be a major factor in achieving victory through its use in submarines and a wide variety of surface craft. Out of its development have grown today's Cleveland Diesel Division (formerly Winton) and the Detroit Diesel Division of General Motors. Buses, tractors and trucks have turned to Diesel power where a heavy job needs to be done at low cost. Two of the most recent applications of two-cycle Diesel power are in deep oil-well drilling and mobile Diesel-electric generating units for utility companies. It is significant that at General Motors' famous Powerama display almost every piece of power equipment was Diesel.

The revolution in American railroading through Dieselization is for the most part over, but abroad a similar change in motive power is growing steadily in importance. And today, at Electro-Motive's sprawling LaGrange plant, engineers under the direction of Research Director Eugene Kettering are shaping the locomotives of tomorrow. Radically different power generating and transmitting techniques — even including atomic energy—are being evaluated. Out of these studies will come still better Diesel locomotives. Rudolph Diesel's relatively unwanted engine of 30 years ago has come a long way, but the end is not yet in sight.

Too Much Standardization?

When Henry Ford moved the Wright Brothers' home and bicycle shop to Greenfield Village, Orville Wright and Ford asked C. F. Kettering to be master of ceremonies during a 30-minute radio broadcast. After Kettering had accepted the invitation, Ford turned to him and said, "Ket, what will you try to get across in the broadcast?"

"I would like to have 40 seconds of that 30 minutes to get across just one thing," Kettering replied.

"If Thomas A. Edison, the Wright Brothers, and Henry Ford had taken IQ tests they wouldn't have gotten in the bleachers, let alone the grandstand." He continued:

"Not because they were stupid but because IQ tests have nothing to do with the fellow who is being tested. They have to do with what someone thinks he ought to be.

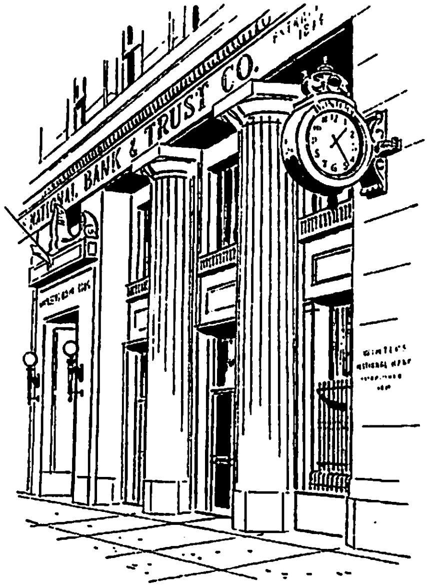
"The person taking the test is what he is; he is what the Lord made him. The test says, 'Well, I think he ought to be like this,' so it lists the questions. Then the educational system is supposed to take the person and make the best out of him, and it is amazing what some of the 'rejects' do.

"There was a genius by the name of Rudolph Hand whose 300th birthday was celebrated about four or five years ago. Rudolph Hand was a very peculiar person. He could barely read or write. He could just make change and tell time.

"Now why should you celebrate the 300th birthday of a fellow like that? Well, he happened to be the greatest painter of birds and animals who has ever lived. Now how would he have gotten along with a nodern IQ test?

"The trouble is, we try to make everybody alike."

The last thing in the world C. F. Kettering expected or wanted to become was a banker. Yet for more than 30 years he has served as chairman of the Board of Directors of Winters National Bank & Trust Company.



The Reluctant Banker

ONE OF THE favorite stories at the Winters National Bank & Trust Company of Dayton concerns the time a bank examiner quizzed "Boss" Kettering on his attendance at Board meetings.

"Mr. Kettering," he asked, "you haven't attended too many Board meetings lately, have you?"

"No, I haven't," Kettering admitted. "But let me ask you a question. Did you find the bank in good condition and is everything in order?"

"The bank is in excellent shape," the examiner conceded.

"Well, then," Kettering said, "did it occur to you that there might be some connection between these two facts?"

Although Kettering tends to make light of his contributions as a banker, his associates at Winters take a different view.

"He was an inspiration to us when he first accepted chairmanship of the bank," one of them said recently. "And he has continued to be an inspiration ever since."

For a "draftee" into the banking business it was a high tribute. The fact was that "The Boss" never had the slightest intention of becoming connected with a bank. Had it not been for a strong sense of community responsibility Kettering would doubtless have turned down flatly an urgent appeal which came to him in August of 1924.

After a busy summer the Ketterings were planning a trip to Europe. Just before they were to board a train for New York prior to sailing, a delegation of prominent Daytonians and several bank officials called at the Kettering home. The visitors came to the point quickly. Because of numerous problems, a change in the ownership and management of Winters Bank appeared imperative to the best interests of the community. Facing this crisis, the group had logically turned to Kettering for help as a result of his outstanding stature not only as a Daytonian but on the national level as well.

Kettering was both surprised and perplexed. His connection with banking had been no more extensive than that of the average businessman. He was usually inclined to quip, "My experience with banks has been that when I needed money I couldn't get it, but when I had plenty of money I could get all I wanted."

It would have been simple to have disqualified himself and to have told the delegation to look elsewhere and find some other person willing to take on this heavy responsibility. Yet Kettering was reluctant to dismiss the matter so offhandedly. He knew how vital a bank — particularly one of Winters' size — was to the well-being of a community. He recalled a bank loan during the formative days of Delco which made the birth of that now-flourishing General Motors Division possible. If it was possible for him to lend assistance in a grave local situation, he felt obligated to do so.

With reluctance and some foreboding Kettering agreed to embark into a new and for him strange field. It was not an easy decision. Many of his friends and associates felt it was a foolish one. They reminded him that fortunes had been lost in far more promising ventures. For an inventor to become the principal stockholder of a bank was not unlike a banker trying to run a research organization. It just didn't make sense.

Doing things that made no sense to most people came naturally to Kettering, however, and becoming a successful banker has proved to be no exception in his exceptional career.

Kettering's first step in his new endeavor was to reorganize the bank completely. In this undertaking he was able to attract to the bank several of Dayton's outstanding financial leaders as members of the new Board or as bank officers. Among these was Walter H. J. Behm, named cashier, who later was to serve as president during the bank's greatest period of growth.

With a new administrative team organized, Kettering turned his efforts toward shaping the philosophy of operation which has guided Winters Bank ever since. In talks with bank officials and other employees, he stressed his viewpoint that service was the greatest commodity a bank had to sell. At that time, such a concept was more ignored than adhered to in the banking field.

"Every bank in the United States receives and pays out money," he reminded the staff. "The chief difference between one bank and another is the degree of service and courtesy each renders."

Kettering had concluded many years before that elections were not confined to political contests alone; they applied to business activities as well. He told the Winters officials:

"A product or a service is being

voted on every day. When people stop coming into our bank it means they are no longer voting for us. To deserve and win those votes we must have a sympathetic, friendly attitude when we are asked to extend credit. Courtesy must be an invariable rule of our operation."

Kettering also felt strongly that the "double-profit" system by which he had measured the worth of other business enterprises was essential to the operation of a successful bank. He defined this double profit as consisting of a fair profit for the business, but a larger one for the customer.

"In banking this means that the bank's customers must make a profit in order for the bank to realize a profit. Otherwise, both are likely to fail," he said.

Perhaps the best indication of the efficacy of Kettering's banking doctrine lies in the record achieved by Winters since the clouded days of 1924 when the inventor was called on for help. That year the bank's capital funds were approximately $1,500,000 and total resources $10,000,000. Today capital funds stand at $14,000,000 and total resources exceed $225,000,000.

Along the way to this phenomenal growth there have been numerous rough spots and crises in which the optimism and confidence so characteristic of Kettering have been of invaluable importance to the bank and to Dayton generally.

"The Boss" has never at any time believed that we are at the end of our frontiers," an associate at Winters explains. "Even in the depths of the depression, he viewed our problems from the perspective of the long pull, and he found cause for optimism when that quality had almost vanished from the nation."

In an article in a popular magazine during the economic paralysis of 1932, "The Boss" wrote:

"Obviously our present difficulties are due not so much to our present faulty thinking as to the thinking we did three and four and five years ago. The time when the man fell out of the airplane was really when accident occurred, not when he hit the ground. Similarly, the time when some of our broken banks really failed was four or five years ago, though it may have been only last fall that they closed their doors."

Just the year before, Kettering had demonstrated in a practical way his conviction that the essentially sound bank would weather the economic storms then lashing the entire banking business. On a somber Saturday morning in 1931, Dayton's largest bank failed to open its doors. Alarm spread quickly through the Dayton community. It was possible that before nightfall the growing panic would envelope other Dayton banks as well. During this crisis, one of the most serious in Winters' 117-year history, Kettering acted decisively. Hurrying to the bank, he spent many hours in the lobby talking with depositors. He assured them that the bank was in sound condition and he guaranteed personally that its resources would be adequate to any contingency. This experience was later re-enacted just prior to the "bank holiday" declared in March of 1933. In both instances, a possible financial panic was averted simply through his personal assurances. It was a revealing indication of the community's confidence in his judgment and integrity.

It is typical of Kettering's broad approach and sound management methods that he has selected capable men to direct the Winters organization and has then given them free rein to guide the bank's activities. One measure of his faith in their abilities is the fact that the bank's Trust Department for a number of years has handled his own business affairs, thereby freeing his time for his many scientific interests. This conservation of time from the standpoint of paperwork is one reason "The Boss" does not even maintain a regular checking account. Last winter when he had occasion to write a check for the first time in a long while, Kettering immediately wired Walter Behm as follows:

"I have written a check payable to the Surf Club. Please see that it doesn't bounce."

For Dayton's reluctant banker, a more unlikely occurrence is difficult to imagine.

Young Man's World

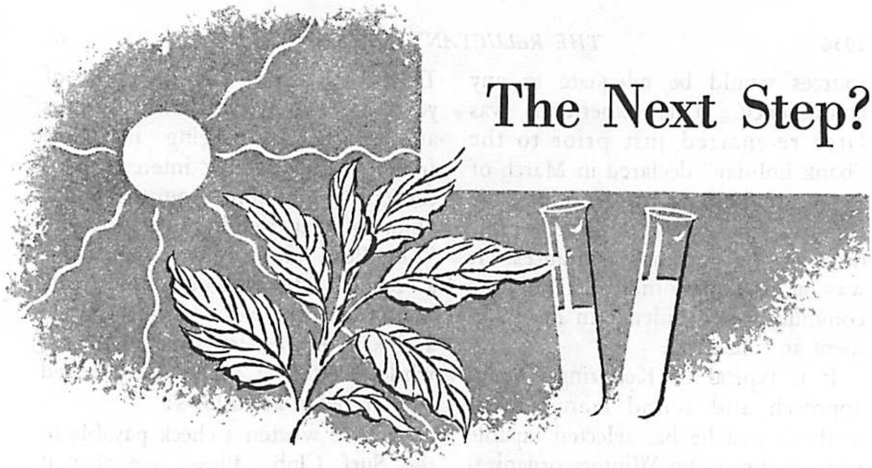
"When you were born, everybody in the world was older than you. Before you were a year old, there were more than two million people in the world younger than you. This ratio increases progressively. At 25, half of the people in the world are younger than you. At 50, you are older than almost 9/10ths of your fellow human beings. You can see for yourself that when you have reached an age of maturity the product you turn out is going to be used mainly by people younger than yourself. And any research goal, therefore, must be chosen in reference to the wants and necessities of younger people. Youth dominates industry, art and commerce. And it rules research." —C. F. K.

Candid Kettering Shots

"Encyclopedic knowledge isn't worth much in the world. They don't pay a very high price for it, because you can buy a whole encyclopedia for $75, on the installment plan, and you don't have to feed it."

"The only place along the road of life where you can sit down on the park benches is immediately in front of the undertaker's office."

"You can send a message around the world in a seventh of a second, and yet it may take years to force a simple idea through a quarter inch of human skull."



The Next Step?

Formed in 1927 to wrestle with scientific problems yet unsolved by man, the Kettering Foundation for more than a quarter of a century has sought the answer to one of nature's greatest riddles.

A FRIEND of C. F. Kettering, hearing of his retirement in 1947, was skeptical. "Ket retire?" he said. "I doubt it. As long as there are problems to solve, Ket's not likely to wind up in a rocking chair."

Subsequent years have borne out the accuracy of this prediction. Instead of retiring Kettering has merely shifted his efforts to those projects for which he previously had too little time. One of these is being conducted with a lack of fanfare which belies its potential importance to mankind.

Within the past decade the power of the atom has been harnessed. But even atomic power — like coal, oil and gas—is based on the earth's supply of raw materials. Such natural reserves will one day be exhausted.

There remains one source of energy that man has only begun to tap—the sun itself. The centuries-old dream of using the sun more efficiently has remained one of science's most elusive goals, even though this inexhaustible supply of energy is basic to all living things.

Throughout his life, Kettering has pondered over this puzzle, and more than 25 years ago embarked on his first scientific quest to pick open some of the locks that guard the sun's secrets. For this effrontery he has been severely criticized in some quarters.

"Man has no business prying into nature's mysteries,' the critics have said. To this, Kettering has replied with some heat and a great deal more truth, "The only secret of nature we are trying to learn is why the human skull is so dense."

With his gift for popularizing the highly complex technical subject, Kettering for many years has referred to his plant and solar studies as "trying to find out why the grass is green." This is adequate as far as it goes, but it has led to some confusion and not a few chuckles. A Westener once wrote to him, "I don't know why the grass is green in your part of the country, but out here it's because of the rain." A well-meaning matron also thought the answer to this tongue-in-cheek riddle was perfectly obvious. "The sky is blue," she said, "and the sun is yellow. Everybody knows that when you mix blue and yellow you get green. Where's the mystery in that?"

Kettering is, of course, deeply interested in why the grass is green; that is, the role of chlorophyll in the chemistry of plants. His curiosity goes far beyond that, however. What he and his research staff are trying to learn is how plants accomplish the many things they do.

How, for example, does a plant take moisture from the ground, carbon dioxide from the air and sunlight from the sky and convert these things into such vital products as food or fuel? Further, how does the plant do it so effortlessly?

"Look around you in any large factory where materials are changed by chemical manipulation," Kettering recently told a scientific group. "You see blazing furnaces, boiling vats and high pressure at work. Look at Nature and you see far more difficult processes carried out at ordinary temperatures and pressures . . . chemists have to batter down atomic gates; Nature opens them with a key."

If man could get his hands on that key, Kettering believes, he could write his own ticket for the future.

"Despite today's farm surpluses," he said recently, "the human race must some day become independent of plant life. There is no reason why we can't make starches and sugars without any growing plants, no reason why we can't get electric energy direct from solar energy. These are tremendous implications but they are not fantasies."

Certainly there is nothing fantastic about the Kettering Foundation's research laboratories adjacent to the Antioch College campus at Yellow Springs, Ohio. Here, in a cloistered, university - like atmopshere white-coated scientists labor patiently with test tubes and microscopes. Daily their collection of facts about photosynthesis — "putting together by means of light"—grows.

How does a plant take nitrogen from the air or from the soil and through its intricate chemistry produce proteins? The human body is totally unable to do so. No animal has this power. Both man and animal must consume the life-giving proteins that are made elsewhere by processes still too strange to understand even in our atomic era.

To Dr. Howard A. Tanner, research director of the Foundation, the plant is far from lowly on the scale of living things. "Consider its almost limitless complexities," he says. "The plant grows; it reproduces; it breathes, it adapts itself to environment, even moving if necessary. In addition it can manufacture products that are beyond the capabilities of animal processes, even beyond the skills and knowledge of our most learned scientists."

But more than intellectural curiosity motivates the research into photosynthesis currently under way not only at the Kettering Foundation but in other places and lands as well. The major incentive is the possibility of opening entirely new vistas of energy to cope with the world's growing population and needs. In his quest for better utilization of the sun's power, man today can be likened to a child admiring the delicacies in a bakery - shop window. About all he has been able to capture is a tantalizing whiff of what lies within.

Dr. Tanner explains it this way:

"Practically all of the energy available to man comes from the sun. The average amount of sunlight falling on a single acre of land in the United States every year is equal to 800 tons of coal. A little of this energy is used directly as heat, and a little more is recovered indirectly by harnessing the rivers and the winds.

"Most of the energy which becomes available to man is first captured by plants through photosynthesis. Yet under the best conditions only a few tenths of one per cent of the sunlight's energy is recovered by all processes."

Foundation scientists are loath to discuss the probabilities of increasing in the near future this percentage, or the magnitude of any possible increase. Theirs is a long-haul project and they do not anticipate that on a certain hour on a certain day the entire murky picture of photosynthesis will suddenly become crystal clear.

Kettering warned them early in the project "to get married and have lots of children" in the event that the research program turned out to be a three-generation job. Yet the pace is quickening. No one in the solar laboratory has yet been able to do with apparatus what the single blade of grass does, and without the slightest sound or fury. Nevertheless, the researchers have now reached the point where they are able to carry out in the laboratory a few of the things a plant does. Even so, Dr. Tanner adds wryly, "They are things the plant does nonchalantly; we have to work like the very devil to duplicate them."

One of the major factors in breaking loose the subject, Dr. Tanner says, is the utilization of radioactive tracer techniques in studying the biochemical processes involved in photosynthesis. "Really great strides have been made in this direction," he adds.

At times during the long and sometimes-groping project a sponsor of less determination than Kettering might have given up. The Kettering Foundation itself was established in 1927 and the studies on chlorophyll began shortly thereafter at Antioch College. In the late 1940's and early 1950's the Foundation expanded its photosynthesis studies by farming out research jobs to various other universities. In 1948 Kettering established a small laboratory at his home, Ridgeleigh Terrace, which grew in importance to such an extent that in 1952 it was decided that a new laboratory should be erected. Completed early in 1954, this is the ultramodern three - story structure which now houses the research program. The sleek new building was ushered into practical use in typical Kettering fashion. Just before Christmas of 1953, before the final touches had been added to the building, "The Boss" threw a Saturday night dance for Antioch students and faculty members. The orchestra played where the enzyme laboratory is now located, in front of a large refrigeraton room, and the non-scientific guests moved through the manometric lab, the enzyme lab and the algae growth room. The "Laboratory Opening Dance" proved to be a whopping success as well as an unusual type of housewarming for the academic world.

Besides its photosynthesis studies, the Foundation since its formation has also spearheaded or assisted in a number of other scientific projects. These include the pioneer fever therapy studies and development of the Kettering - designed fever machine used extensively in treating venereal diseases prior to the discovery of penicillin. The Foundation has also supported numerous cancer studies.

Throughout the long struggle with photosynthesis, Kettering has remained patient with difficulties and unperturbed by setbacks. He confided to a friend that photosynthesis "presents a limitless frontier for discovery, invention and research." This is true, he added, no matter how many persons say it cannot be accomplished by man.

Today Kettering spends a great deal of time at the Foundation building following closely the work that is progressing at an ever faster pace. His optimism regarding its ultimate success has never been higher. After a lifetime of wrestling with scientific enigmas, "The Boss" is in a position to know when the pieces are beginning to fit together with some semblance of order. Already a few of the wraps have been removed from the process of photosynthesis. Others appear certain to follow. There is now substantial evidence that the master key to plenty may not lie far from man's grasp. If so, finding out "why the grass is green" may prove in the end to have been the most significant of Kettering's struggles with the unknown.

The world hates change, yet it is the only thing that has brought progress.

A research problem is not solved by apparatus; it is solved in a man's head.

It is not what we know that is so important, it is what we do not know.

—C. F. K.

In 1940 C. F. Kettering set up the National Inventors Council. Ever since then he has served as chairman of this agency which mobilizes the brainpower of American inventors for national defense.

Harnessing Inventive Genius

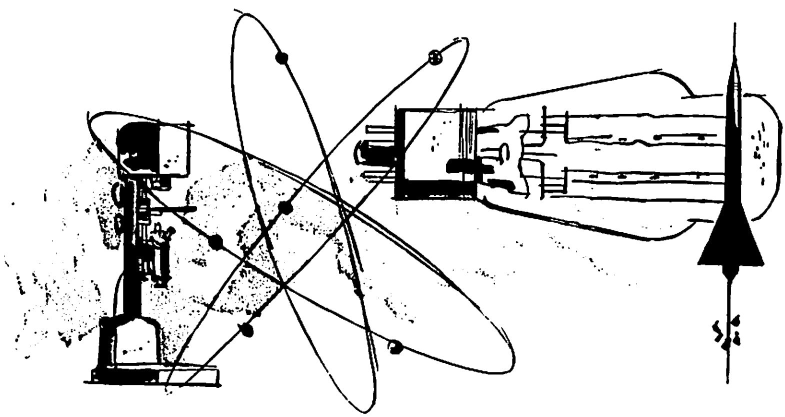
By John C. Green
Director, Office of Technical Services

DURING THE Korean War a young World War II veteran went to work on an idea for saving American lives. During his experiences in the Pacific he had seen many landing craft stuck on enemy beaches after delivering their loads of men and materiel.

The ex-serviceman sat down and drew up blueprints for a device which he thought would offer a practical solution to this serious problem. It consisted of a large bulldozer blade for the ramp of the landing craft. When the ramp is lowered to discharge the assault forces, the blade digs in and pushes the craft upward and backward hydraulically.

The young man sent his suggestion to the National Inventors Council in Washington. The Council found this new approach to an old problem worthy of further consideration. It promptly passed the idea along to the Navy, where the device is currently under tests.

This suggestion is representative of the many ideas which are being channeled today to the Armed Forces through the National Inventors Council. Through the Council any civilian inventor, amateur or professional, can contribute to his nation's defense without going through a maze of government offices or becoming entangled in red tape.



The Council is an industry-government organization designed to make available to the Armed Forces the brainpower of American inventors. Behind it are two basic facts:

1. Science and technology are of increasing importance not only in war, but in maintaining a strong defense to deter aggressor nations.

2. Most revolutionary war inventions have originated in the minds of civilians. For example, in his own era the war machines of Leonardo da Vinci were much more important than his artistic efforts. More modern contributions have included Eli Whitney's first rifle with interchangeable parts and John C. Garand's famed M-1 rifle of World War II.

The Council was formed in 1940 following discussions between Lawrence Langner and then Commissioner of Patents Conway P. Coe on the need for a means of mobilizing the nation's inventors for defense. The idea received the endorsement of President Roosevelt, who immediately asked C. F. Kettering if he would organize such an agency and serve as its chairman.

Through Mr. Kettering's efforts, approximately 20 outstanding inventors, scientists and industrial research men with specialized experience in developing inventions agreed to serve on the Council without pay as a public service. Besides civilian members, the Armed Forces and other government divisions are also represented. The Office of Technical Services in the Department of Commerce is the staff agency for the Council.

One of the Council's first tasks was to supply inventors with information about the technical problems of the military. It set up an information program to explain its services and today periodically publishes lists of needed inventions. Its second job is to screen all submitted ideas so that those with possible merit can be routed quickly into the proper military channels. The regular staff does the initial screening. Then the Council, after further review of the ideas, submits them to separate committees covering the entire field of military needs. Each Council member serves as chairman of one of the committees.

During World War II, some 208,975 inventions and ideas were evaluated. Of these, 8,615 were considered of sufficient merit to be classified and more than 5,000 were sent to the various services for review. Nearly 1,000 ideas eventually were selected for additional investigation, development and testing. How many inventions were actually put into production will probably never be known, since the Council usually does not follow the progress of the suggestions once they have been referred to the Armed Forces.

It is known, however, that a great many of the ideas submitted through the Council have been important in the saving of lives and dollars. Among the better known of these was the World War II mine detector, which grew out of a device originally intended for hunting buried treasure.

The Council also played a role in

the development of the mercury-cell battery, now available commercially, which is used to power "walkie-talkies" and other military field equipment. Early in World War II, it was found that regular dry batteries were unsatisfactory for use in the South Pacific. They were heavy and expensive to ship and by the time they were finally used frequently had lost their strength. Just about this time a young inventor submitted to the Council an idea for an improved Arctic-type battery. At that moment there was no demand for a battery which would operate in extreme cold, but the inventor was told about the need for a tropical-type battery. He tackled the problem at once, and a short time later submitted the now widely used mercury-cell battery. It was a typical example of how the Council serves to bring together the problem and the inventor to the benefit of the nation.

A third widely known World War II development was a set of signal mirrors which became standard equipment for U. S. fliers, saving the lives of many airmen forced down at sea. A California garage mechanic had developed his mirror as a signaling device for members of his Boy Scout troop. He submitted the idea to the Council when he heard there was a pressing need for such a life-saving device.

Another function of the Council

INVENTORS VS. PEOPLE

"Inventors are almost a disappearing group. Most people speak of them as longhairs or screwballs, and we are so small in numbers that we dare not say what we think about people.

"What is the difference between most people and inventors? For one thing most people are interested in where they came from. Inventors are interested in where they are going.

"Perhaps the difference between the scientist and the inventor can best be illustrated by a loom, where you have the threads called the 'warp' running lengthwise of the loom; these represent your physicists, chemists, biologists, and so forth. The thread that's put in at right angles by the shuttle is the 'woof;' that represents the work of the inventor.

"The inventor cannot be just a physicist, a chemist or a biologist; he has to be whatever is necessary to get the job done. He may have to use some physics, some chemistry and something else. He has got to tie the threads together.

"Now, if you don't think the 'woof' man is essential, try to sleep in a scientific hammock and see what happens!"

—C. F. K.

is illustrated by the development of aerial refueling methods. Early in World War II one of the Council members recalled patent work he had done for a British company on aerial refueling. He called this to the Council's attention. The Council then brought together all the known information of this subject and turned it over to the Air Force. The result was an experimental project conducted at Wright-Patterson Air Force Base which later led to today's extensive use of aerial refueling in extending the range of airplanes.

Not all the motives behind suggestions received by the Council are patriotic. Now and then an inventor, for the deposit of huge sums of money, offers to reveal "a secret that will win any war." One correspondent admitted that he was about to be drafted and hoped that an accepted suggestion or two would spare him that fate. The frequency of ideas he submitted steadily increased as the date of his induction approached, but in the end he was forced to make his contribution to the nation as a member of the Armed Forces rather than as an inventor.

The Council has also received an ample supply of bizarre and fantastic inventions and ideas. One of the strangest concerned incendiary bats. A world authority on bats suggested equipping certain large species with incendiary time bombs and releasing them over enemy cities at night. His theory was that the bats would seek out attics and other hiding places in buildings. Then, at a set moment, a timing mechanism would explode the incendiary bomb, setting fire to the structure. Surprisingly, this idea was not as far fetched as it might seem. Tests indicated that it was practicable, although the development of more efficient incendiary methods eventually spared the bats from such a fiery fate.

One inventor mailed bomb models to the Council with no warning on the package, although a note inside cautioned that the bombs were loaded and might explode. A South American inventor sent a sample of an anti-personnel bomb which he had loaded with itching powder, much to the discomfort of those who unpacked it.

Throughout its existence, Mr. Kettering has taken a keen interest in the Council and its activities and has given invaluable guidance to its staff. His extensive experience in the development of inventions and new processes has enabled the Council to set up an operating procedure which assures maximum efficiency and minimum delay in processing suggestions. In Council meetings, Mr. Kettering is able to bring his intimate knowledge of the auto, power and transportation industries, among others, into play in dealing with current problems. In addition, his far-reaching prestige gives an idea of stature it would not otherwise enjoy.

Under this kind of direction the Council is continuing to utilize America's inventive genius in the constant struggle to keep our nation strong.

C. F. Kettering has been interested in education all his life. He is still a schoolteacher at heart, although his classroom has expanded from one room to a much broader audience.

This Business of Education

By Norma Bixler

BACK in 1896, 20-year-old Charles F. Kettering was teaching at a one-room schoolhouse near Loudonville. It was in the days of rote learning, rigid discipline, dedication to the three "R's".

The young schoolmaster continually threw his district into a turmoil with the things he and his 30 pupils did, the trips they made, the sights they saw. They even walked a round trip of 10 miles to see a strange machine called an "X-ray" which showed them the bones in their hands.

Even at 20, Kettering knew that people learned not only with their minds, but with their eyes and ears and hands. Perhaps then it was an instinctive knowledge. But the mature man in his forties, with many years of thought and experience behind him, still believed the same thing.

He was in his forties when he met Dr. Arthur E. Morgan, who was to become president of Antioch College. Their first common interest in education was not the college but an elementary school called the Moraine Park School in Dayton.

Kettering was already interested in photosynthesis and had built a large greenhouse filled with growing plants. When a search was made for a building to house the new school, he suggested the Kettering greenhouse to Dr. Morgan.

"I'd rather raise kids than cucumbers," Kettering told his fellow engineer.

And that's where the school was first established, with a floor added, and some of the panes of glass painted to soften the light and heat.

Perhaps it was in their discussions about Moraine Park school, perhaps on some of the drives when Dr. Morgan accompanied the imaginative General Motors research director to schools in the area to speak on education. But somewhere Morgan must have told Kettering of some of the dreams he had for a college. It would be an experimental college where students would learn not only from books but from practical experience.

The chance to try out his ideas came sooner than either of them had expected. Antioch College, a proud school with a fine tradition, was in a life-and-death financial struggle. Efforts to turn it into a national YMCA college had failed because of legal difficulties over its original charter. Morgan was elected to its Board of Trustees and in August of 1919, presented his dream which the trustees adopted. In June of the next year, Kettering was elected a trustee also, and was one of those who elected Morgan president of the college the following month.

This was the beginning of a relationship which has continued for 36 years between Kettering and Antioch. Kettering's interest in education has not been limited to Antioch, but more of his time, his energy, his money have been invested in the Yellow Springs college than in any other educational institution.

One of the cornerstones of Morgan's plan for the college was the introduction of the co-operative plan. This program, which divides a student's months between classroom study and a practical, workaday job, is also one of the cornerstones of Kettering's interest in the college.

The plan originated at University of Cincinnati in 1906, for engineering students. As developed at Antioch, it is compulsory for all students, whatever their field.

Kettering has described the difference between a traditional college and Antioch by comparing butt-welding and lap-welding. The first just welds together, end to end, two pieces of metal. But in lap-welding, the two pieces are overlapped and then welded together. This, he points out, makes a much stronger joining.

Education, he says, consists of what you learn from books and what you learn from practical living, but usually the two learnings simply follow one after the other, end on end. At Antioch, he believes, the two overlap and both gain strength.

Kettering was never a man to believe in an idea and then just give it lip-service. To Antioch and its four recent presidents, he has given his strength and his understanding as well as his time and his money.

His first gift, and perhaps his greatest, was one of faith. The college of which Morgan became the new president in 1920 included three main buildings, erected in 1853, and still not modernized. The first necessity was for money to install central heating, plumbing and running water in those pre-Civil War buildings.

The money, $300,000 of it, was borrowed from a bank, and Kettering signed the college's notes.

"We could hardly have survived without it," Morgan said recently, recalling those early days. "He knew how great a risk he was taking."

It was 1943 before the notes were all paid off and burned in a joyous ceremony outside the college's main building, a ceremony which Kettering attended and to which he had substantially contributed through the Kettering Foundation.

In 1930, the college's Science Building, a gift from Kettering, was opened. Its top floor was set aside for his staff of scientists engaged in photosynthesis research. It does not bear his name. Instead, just inside the building's main entrance is a framed portrait of the man and underneath a direct quote from him:

"This is a place to work in; not a monument to anybody."

Last year, a new library was dedicated on the Antioch campus. In a moving and loving tribute to "Mrs. Ket", the inventor explained to his audience why the library was called "The Olive Kettering Library." It was not a memorial; she wouldn't have liked that, he said. It was, and is, an "appreciation."

Today, contractors are busy on a site just across the campus where work has begun on a Union Building, to house student lounges and offices, a cafeteria and restaurant. On the opposite corner, the old Horace Mann Library has been remodeled as Horace Mann Hall, with classrooms and offices for the humanities. These two are also Kettering's gifts.

One hardly needs to explain that Kettering is a V.I.P. on the Antioch campus. Yet there is something different about the way he plays the role, and about how Antioch plays hers. To be sure, on special occasions, Antioch and Kettering can both put on their best bib and tucker and Kettering can and does play the honored guest while Antioch plays the honoring host. And they both mean it.

But their everyday relationship is a much more casual, comfortable affair. No one can roll out the red carpet two or three times a week at unannounced hours as if it were a tarpaulin to cover a big league infield during a storm. Kettering has always been a frequent, unannounced visitor on campus. Since the Kettering Foundation building was erected on the edge of the campus, where almost all the photosynthesis research is now centered, he is usually on campus two or three days a week. Most faculty and college guests usually ate in the tea room before it was torn down in June. Students prefer the cafeteria, especially at lunch. So does Kettering. It saves time.

But the rather shabby and often noisy quonset huts are not the conventional setting for a V.I.P.

These days when he finishes his lunch, he walks down the street and plays the sidewalk superintendent for a while, watching the workmen at the Union Building, just as a year ago he used to drop in at the library when it was being built.

The people he meets on such a walk or on any walk across the campus may include the president of the college, a student research assistant, someone from one of the college offices, somebody on the maintenance staff, a science professor. From each comes the personal greeting, to each goes the personal response.

It's terribly hard to treat as a V.I.P. a warm human being who is a familiar member of the community.

But a really perceptive reporter would realize that familiarity and lack of distance are not the only unconventional elements in the way Kettering plays his role and, perhaps more especially, the way the college plays hers.

He might not, at first, believe his own conclusions but he'd have to admit, after talking to people in the college community, that the first spontaneous reaction to Kettering is not one of respect and awe for a V.I.P. benefactor, but of affection and delight in Kettering, the man.

For Kettering is a breaker of graven images in the academic world, too.

A few months after the library gift had been announced, he was speaking in Antioch's Kelly Hall to chemists from Cincinnati, Columbus and Dayton, members of the American Chemical Society.

He was talking to them about research, warning them about approaching it traditionally, with the first step the reading of all the literature on the subject in the journals. He stopped in mid-speech, turned to Dr. Douglas McGregor, then president of Antioch, who sat on the platform behind him.

"You know, Doug," he said conversationally, "when we build our library over there, I think we'd better engrave a sign over the door, 'Enter at your own risk.' "

The following year, he was delivering the Commencement address and he gently ribbed the graduating class, one-third of whom were going to graduate school, about specialization.

"Specialists are authorities on something that isn't known," he told them. "Once a thing is known, the only authority is the fact. The first time you do anything, you're an amateur on the subject. We live only one life so we're all amateurs all our days."

At the library dedication he said,

"I started as a schoolteacher and I've been interested in education ever since. But they've never admitted me to the inner circle of educators because I'm an inventor and people think inventors are screwballs."

That time, though, almost as if they were calling his bluff, his fellow trustees within a few hours chose him as the chairman of the Board at Antioch, a position he holds today.

Samuel B. Gould, today's president at Antioch, says he thinks Kettering has more insight and perception about the present problems of education than the great majority of professional educators.

Antioch may know him best, but his interest in education has never stopped at the edges of the Yellow Springs campus. He has been a friend and benefactor of both Earlham and Wilmington Colleges. Two of his staff at the Foundation commute to Wilmington to teach science classes. He is equipping the laboratories in the new Xenia High School. For several years, the Kettering Foundation has granted college scholarships to young high school students planning to major in science.

There is his intense interest and pride in the recently opened General Motors Technical Center. And he is also a member of the Board of Trustees of his own alma mater, Ohio State University.

As he says himself, he's been interested in education all his life. He still believes today what he believed 60 years ago, and he's willing to invest his time and resources in backing that belief.

"If an education can give you these things, teach the duty of citizenship, teach the growing generation how to make a living, and contribute our knowledge to the advancement and welfare of each other, I believe it will go a long way toward wiping out this world-wide dissension which we all know is so prevalent today."

He said that a long time ago. It is still a sound definition of education today.

Ketteringisms

A man must have a certain amount of intelligent ignorance to get anywhere with progressive things.

Incurable diseases are only those the doctors don't know how to cure.

Engineering must partake as much of economic horse sense as it does of scientific principles.

We should all be concerned about the future because we will have to spend the rest of our lives there.

"Cancer University"

At the Sloan-Kettering Institute for Cancer Research in New York City "a few labor unceasingly that many may live." In the following article the Institute's director describes how C. F. Kettering's interest in this project pioneered by Alfred P. Sloan, Jr., was aroused, and what his activities have meant in man's dramatic battle with cancer.

by C. P. Rhoads, M.D.
Director, Sloan-Kettering Institute

THE FIRST meeting with Mr. Kettering to discuss the possible creation of an institute for cancer research took place in the early summer of 1945. I was just out of the Army and at the suggestion of Mr. Frank A. Howard, Mr. Kettering joined us for lunch. It must be said that he was not terribly enthusiastic about the plan. The conversation was exceedingly general, and every effort to develop on Mr. Kettering's part a real interest in the plan ended in failure. Despite this, he was most thoughtful in discussing the matter and pointing out certain principles which should apply to any scientific activity of the type contemplated. The luncheon broke up with the feeling that Mr. Kettering would go along with the recommendations of Mr. Alfred P. Sloan and his associates, but would not participate to any great extent personally until he knew much more of the details and the personnel involved.

In retrospect, this was, of course, a completely understandable position. He had already supported a number of activities in cancer research. Furthermore, in this preliminary discussion, no concrete plan of operation, with a well defined and obviously attainable objective, was presented to him. As a man of action, his whole life had been devoted to the completion of tasks which could be clearly envisioned, easily understood and approached quickly and in orderly fashion. He was not interested in theoretical discussions.

Not long after this first meeting, I was asked to meet Mr. Sloan for lunch in the General Motors building. Mr. Howard was present, and the conversation quickly indicated that considerable discussion had already gone forward of the possibility of setting up an institute for cancer research, adjoining and integrated with the Memorial Hospital. Mr. Sloan was well informed and deeply interested. His questions were thoughtful and very much to the point; so much so that I found it difficult to give really reliable and well-founded answers. His first question was whether I thought that, if an institute were created, it could function effectively with such a cancer hospital as the Memorial. My answer was yes, if the administrative lines were carefully established and maintained. He then asked how large an institute would be required to contain both the fundamental and applied laboratories needed for a uniquely broad, comprehensive and potentially successful approach to the cancer problem. I indicated that, on the basis of wartime experience, something in the range of 80,000 square feet of laboratory space, would be required at least. This was based on the belief that we would need in cancer research exceedingly basic laboratories in the fields of steroid chemistry, virology, immunology, general endocrinology, nucleic acid chemistry and toxicology. My figure was a guess, however, made from a rough recollection of the extent of the Rockefeller Institute laboratories and those in medical schools familiar to me.

The third question asked by Mr. Sloan was how much I thought would be required annually to maintain a laboratory of the type proposed. Again, since I had no warning that this question would be asked, I could only guess quickly from limited personal experience. I gave him a figure of $200,000 a year. This was based upon something recalled concerning the earlier cost of operation of the laboratories of the Hospital of the Rockefeller Institute for Medical Research. Furthermore, it was my impression that the figure was not too far out of line at the time with the pre-war research budgets of certain small medical schools. I had had the conviction for years, with Mr. Reginald G. Coombe, that to attain our objective we would have to set up an organization as comprehensive, or more so, than that of a medical school. It was from this view that Mr. Coombe phrased our objective "a cancer university".

This momentous luncheon, at which a skeleton plan was developed, ended with two questions: whether the whole arrangement discussed was likely, in my opinion, to result in substantial advances toward the better control of cancer in human beings; and whether it would provide something which did not already exist elsewhere. My answers to both were in the affirmative. During the war years with the Army's Chemical Warfare Service, I had become thoroughly convinced, as had a number of my associates, that better cancer control had never seriously been sought, certainly never by the orderly methods of investigation which had been developed and had operated successfully to achieve the solution of major problems of military medicine.

It should be thoroughly understood that, whereas, the question of financing a program for a ten-year period was considered at the outset, there was at no time any expectation or assurance, or even discussion of

CANCER SCOREBOARD

How near is a cure for cancer? No one can say with certainty. However, as a result of the research programs of the Sloan-Kettering Institute and similar agencies and groups, hope for eventual victory has never been higher. Dr. Rhoads, director of the Institute, believes that more progress has been made during the past 10 years in the fight against this major killer than was achieved in the preceding 100 years. Some of the important accomplishments to date are:

... In cases where cancer can be treated by surgery and irradiation, when it is still localized to a single organ, cure is today almost certain. By earlier discovery and treatment, it is believed the overall cancer cure rate by these methods can be almost doubled. At present, 25 per cent of all cancer victims recover and all of these are cured by surgery and irradiation. This low rate of recovery prevails because only 25 per cent begin treatment while the cancer is still confined to a single organ. In the remaining 75 per cent of cancer cases, the disease has spread to other parts of the body. In such cases the cancer cannot be removed and must be attacked through chemical means. Thus, the researchers hope to find a chemical agent that will destroy such widely scattered cancer cells, just as penicillin destroys certain bacteria throughout the body. The Sloan-Kettering Institute is in the forefront of this every-continuing quest.

... Chemical agents have already been made which slightly and only temporarily restrain the growth of certain forms of widely spread cancer.

... There is some knowledge as to how these chemical agents work, and there is every reason to believe that new, more powerful agents will be developed.

... Although animal cancer is different than human cancer some types of transplanted animal cancer can now be cured chemically. Also, there is evidence that both human and animal cancer have certain common properties which may prove important in finding a chemical cure for human cancer.

the possibility, that a cancer remedy would be had within the first decade of operation. The ten-year figure was arrived at simply in order to have enough assurance of continuity for the staff to enable us to procure individuals of supremely high intellectual capacity.

At the next meeting Mr. Kettering was present. I had the impression that Mr. Sloan had been discussing the plan in great detail with him, and that he was a little uncertain to what extent he was expected to participate. The conversation at this meeting was almost entirely on matters of structure. Mr. Kettering pointed out many of the palpable absurdities in modern buildings and indicated the important points to be considered. I recall well his active reference to such matters as the extravagant construction of unnecessary windows and the points he made about the proper covering of floors. Most important of all, however, was his insistence on sufficient flexibility of structure so that the constant shifts required by incessantly changing programs could be made. For this reason, from then on we began every conversation with the architect with the statement that we were less concerned with the appearance than with the ability to reach any part of the building with any service, at any time, within a few hours, and that every structure must be susceptible to modification. For the first time, on this occasion, I felt that Mr. Kettering was really developing a deep personal interest in the plan which had been proposed.

The next meeting involved a discussion with counsel of certain legal considerations. Mr. Kettering did not take a very active part in the conversation, but rather reiterated emphatically once more his feeling that certain principles of operation must be adhered to, and that if we dealt with individuals of good will and real ability, the terms of the contract would make little difference. I may say that in this point of view, expressed so frequently over the years in my discussions with Mr. Kettering, he has shown the most uncanny judgment in the selection of individuals with whom no contracts are needed, but who are capable of the most devoted, enthusiastic and productive co-operative work. I have not the slightest doubt that this has been one of the most important factors in Mr. Kettering's prodigious administrative success, despite his claim that he is only a "screwdriver and pliers inventor.

Essential agreement on all the details had been arrived at by mid-July of 1945, and for all practical purposes the plan was consummated. It was arranged by Mr. Sloan that there would be, in the General Motors building on the 7th of August, a public announcement at a press conference. In preparation for this, a carefully worded newspaper release was drawn up by the General Motors public relations organization. The press, particularly the news science writers, were alerted, and agreed to be on hand. At that time, although we knew of the Manhattan Project, none of us realized that the first atom bomb had been detonated in the New Mexico desert, and that one would be dropped on Japan in the near future. We woke on the morning before the announcement of the Institute's creation to read of Hiroshima and that prodigious damage had been effected which might well terminate the war. It is hard for us to realize today how incomprehensible to a large part of the population was the term "atom" and its component particles, particularly the idea that by fission there could be released energy in amounts and of an extent which had never before been dreamed of.

The consequence of all this was that on the day set for our announcement the news science writers were busy refreshing their knowledge of atomic physics, and very few were able to come to the meeting as they had planned.

One in particular had dreamed for years of the possibility that industry would institute a program of cancer research and would apply to it the organizational principles which had been so successful in solving industrial problems. When this writer learned of the fact that there would be created an institute bearing the name of a great industrialist, Mr. Sloan, and a great industrial scientific worker, Mr. Kettering, he jumped to the conclusion that these gentlemen would operate the Institute along industrial lines. As a consequence the headline, in one of the most widely read national newspapers, carried the statement "Kettering will direct." From these conclusions, arrived at hurriedly and without factual knowledge of the plans for the Institute, there was created among the scientific community a very real feeling that an industrial laboratory was being created to solve a basic problem in medical research. Rightly or wrongly, this feeling gave rise to a great deal of unjustified opposition. The gossip quickly spread that those who would work in the Institute would not be permitted to publish under their own names, and that important information would be withheld pending the development of patent rights.

It should be said in this connection that in the eleven years of the Institute's existence, there has never been the slightest indication, on the part of either Mr. Sloan or Mr. Kettering, to direct, to plan or to influence the course of our scientific work. On the contrary, indeed, they have been almost incredibly willing to expend their personal monies on the simple recommendation of the scientific staff and the Director. Only two recommendations have been made by either man; both have been made repeatedly and vigorously. These are: We must have the very best scientific staff attainable; and these individuals must have what they need to work with. It is hard to conceive of a more generous and a more liberal policy.

During the planning and construction of the SKI building, Mr. Kettering took little active part. I am sure that he regarded these matters as being in competent hands, and therefore no longer of deep interest to him. Rather, at the meetings of the Trustees, he kept emphasizing the importance of having a clearly thought out, well documented, and objective program.

Once more, in retrospect it is easy to see that he was fearful that our enterprise would become diffuse, unoriented, and without a well-defined goal. He said, over and over again, that he did not see how anybody could end up anywhere unless they tried to get somewhere. He quoted repeatedly his own disappointments which had followed his donation of funds to investigators for specific purposes they had outlined, but which were promptly forgotten once the funds were received. This statement, however, should not be misconstrued as indicating that Mr. Kettering either discounted or doubted in any way the exceedingly essential value of fundamental information and scientific initiative. He felt strongly, and stated emphatically on many occasions, that one could not expect to achieve an important goal without a solid foundation of the most basic scientific facts. He did believe, however, that one should set up a pre-determined goal and that one should select, as far as possible, those scientists who had the fundamental techniques upon which could be erected a structure of fact suitable for its attainment. I think that his point of view is, and was, best exemplified by two stories. The first was the aphorism that one could stumble onto important things just as well, indeed rather better, if one were going somewhere, than if one sat still and contemplated. By this he meant, of course, that the actual performance of experiments is the best stimulant to thought, and provides the greatest opportunity for chance observations. It implies, furthermore, distinct distrust of the philosophic and wordy approach to a practical problem. Dogma and esoteric discussions have been Mr. Kettering's prime moral enemies in all the years of my acquaintance with him.

During the period of the Institute's construction, his change in attitude was perceptible. From disinterest in anything except general principles which he had learned were applicable to research, he came more and more to appreciate the details of the fundamental investigative program which we planned to incorporate in the project. Furthermore, he became really interested in the principle which we have called "bench - to - bedside research," in which one draws from actual experience with patients such suggestions as may give rise to the most important type of basic scientific enterprise. Conversely, the clinician who is genuinely interested and competent in the scientific method draws constantly, from the non-clinical scientist, new ideas, new tools and new abilities to handle disease more effectively.

I do not recall real enthusiasm on Mr. Kettering's part, however, until he came to the laying of the corner-stone of the Institute. For the first time, clearly, he felt that a dream which he had regarded with some concern, if not with actual scepticism, was coming to fruition. As a man who is concerned with facts, this conversion of idea to solid structural form gave him, perhaps, satisfactory assurance that things were really going forward.

The next step in our work with Mr. Kettering came when the building was completed, and we held its dedication. Dr. Eric Boyland and Dr. Alexander Haddow, from the Chester Beatty Institute in London, joined us, and were given the Judd Award at this time. I had almost forgotten, during the following ten years, what an intensive job was involved in getting ready for this ceremony. The devotion of the staff and of the Trustees was particularly outstanding. Notable during the afternoon exercises were the talks, informal as they were, of Mr. Kettering, of the Surgeon-General, Dr. Leonard Scheele, and of Mr. Albert Lasker. All those who spoke did so with deep emotion, and obviously firm resolution to see through to the final end this job which we had undertaken.

In the early days of the Institute's activities, before the building was completely ready for use, the meetings of the Trustees were held at first at the University Club and later at the Union Club. It was at the former that one of our more difficult and serious problems was faced. At this time I was functioning not only as the Director of the Institute, but also as Chairman of the Committee on Growth of the National Research Council. This committee was the one to which by contract the American Cancer Society had turned over the function of recommending on grants-in-aid in support of cancer research. This support was derived from the program newly developed by a new body of Trustees, principally lay, devoted to furthering the scientific method toward the solution of the cancer problem.

In the early days of the existence of this Committee, in 1945 and 1946, a policy of small grants-in-aid, recommended by reviewing panels of experts, was adopted. Many of us had hoped that there could be developed coincidentally a broader policy which would also permit, in the exploitation of the leads developed by these small grants, the allocation of major sums to major institutions permitting large-scale and long-continued work of particularly important and pertinent types. Much opposition had developed to this principle of institutional or block grants, and the American Cancer Society resolved the problem by making two initial grants of substantial size. Without the approval of the Committee on Growth, it decided to offer a grant of $250,000 annually to the Sloan-Kettering Institute, and one of $50,000 to the Barnard Free Skin and Cancer Hospital in St. Louis. This intention was announced to the Trustees of the Sloan-Kettering Institute at a regular meeting. It aroused much discussion, at which concern was expressed over the possible repercussion of such a large sum coming to the Institute of which I was Director, by an action transcending the recommendations of the Committee of which I was Chairman. Despite concern over this plan, acceptance of the grant was voted by the Trustees. It was felt that the principle was correct, that the institution was justified in taking this type of grant, and that the Society was justified in proceeding in a matter of such basic policy without the approval of its Committee on Growth.

Mr. Kettering was most helpful and understanding of the problem raised by this first large institutional grant by the American Cancer Society to the Sloan-Kettering Institute and in some part his influence led me to resign my position with the Committee on Growth. Events since that time have adequately confirmed the wisdom of the decision. It became clear, as Mr. Kettering pointed out, that one cannot function as a philanthropist and also as the principal representative of a recipient of philanthropy. Because of this conclusion, so adequately borne out by events, it has been our principle since that time not to serve on any body allocating funds in support of cancer research.

When the present building really came into operation, in the late spring and summer of 1948, Mr. Kettering began to take a very much more active interest, particularly in the nucleic acid program developing at the Institute. It happened, by sheer coincidence, that this program fitted nicely with the planning of Mr. Kettering concerning his own interests in Dayton and at Antioch College. His interest in the action of chlorophyll and the fixation of hydrogen in carbon-dioxide had progressed to a broad consideration of pre-biological chemistry. This led him inevitably to the role of catalysts in both hydrogen and nitrogen fixation, and the possibility that one could derive from oxalic acid something resembling a self-replicating unit of the type of nucleic acid. Once more, the clarity of vision exercised by Mr. Kettering in our planning was amazing. The recent papers of Calvin and his associates from California, as well as of the Urey group from Chicgo, make it perfectly clear that once more he was ahead of his time. The work he has now begun at the Kettering Institute in Yellow Springs, Ohio, may lead to important discoveries in the extraordinarily fundamental field of the origin of organic material. His deep and abiding interest in the anabolic function of vegetable life made him quick to understand the action of specific antimetabolites in their potential ability to control cancer in animals and in man, and to appreciate the rationale of our program.

It was a little later, when Mr. Kettering's sister became ill in Mansfield, Ohio, that he asked me to meet him to go over the case with her local physician. This was a memorable occasion. It was a wet, early October Saturday and Mr. Kettering and I drove and talked from Detroit to Mansfield. Following the meeting with his sister and the physician, we drove on in the rain to Loudenville. The occasion was a rather sad one, and this led Mr. Kettering to a long and most revealing description of his early years in that area. He showed me his little house, just constructed in Loudenville, the mill where he had his first job setting the valves on a Corliss engine, when he was a student at Ohio State, and we had supper with his second sister on the old farm.

It was on this trip that I learned for the first time of how he had initiated the local high-school band, now so popular throughout Ohio, and how he started the Flxible Bus Co. to give Loudenville some kind of a productive industry, when he saw the young people all leaving for more industrialized communities.

It is very hard to express adequately the impression made upon me by this trip. For the first time I felt that we had in Mr. Kettering not only a devoted supporter, but a real confidant and an inspired leader. This, indeed, was the first time I had heard him describe in detail how he felt we should operate the program of the Institute by principles which his long, unique experience had proved to be sound and productive. Once more, he emphasized repeatedly his thorough conviction that important advances are made only by the most fundamental types of scientific work conducted by the most competent individuals. But, on the other hand, he felt equally convinced that this should only be done in those areas which clearly pertained to our defined objective, cancer control in man. He was thoroughly unsympathetic with the policy so frequently observed by him in other institutions, where the objective was lost sight of in an effort to follow an easy path to immediate, though minor, gains of academic prestige. Here, for the first time, he told me the story of the man who looked for his pocketbook where the light was good, but not in the area where he had lost it. I know of no anecdote which is so pertinent to our problem as this one.

Somewhat later, in the early fifties, I explained to him our need for direct co-operation with a first-rate group in the synthesis of compounds of potential antimetabolite action on nucleic acid formation of specific types. I told him that the best group at the moment in this field was that of Dr. George Hitchings at the Burroughs - Wellcome Company. Mr. Kettering immediately saw the importance of this matter and offered to finance a program of synthesis in these laboratories. He was careful to point out, however, that this would be done with the understanding that the compounds be available to any qualified scientific worker; that he was not interested in any exclusive arrangement which could be misconstrued by the scientific public at large. This conversation led to the contract with the Burroughs-Wellcome Company which has been a most productive one. Here, once more, his ability to discern those individuals with whom one could work productively, and his lack of confidence in contractual terms, were well exemplified. His statement, made repeatedly, was that if you need a contract you are dealing with people whose word is not to be trusted, and you had better find someone else to work with.

It was not long after when it became apparent that Dr. Howard Skipper, at the Southern Research Institute, who could not be persuaded to leave the South, was developing a position in cancer research which would justify the creation under him of a laboratory integrated with the Sloan-Kettering Institute. The possibility of doing this was greater because of Mr. Kettering's great friendship for Mr. Thomas Martin, the Chairman of the Board of the Southern Research Institute. The possibility of setting up an autonomous laboratory, but one working with complete exchange of information with the Sloan-Kettering Institute, was of great interest to Mr. Kettering and to the Trustees of the Southern Research Insitute. This led to a series of meetings, both in Birmingham and in New York, between Dr. Skipper, Dr. William Murray, Mr. Martin, Mr. Howard, and myself. When he had arrived at a plan which seemed to be mutually agreeable, for the construction and for the financing of the operation of a laboratory in Birmingham, the matter was presented to Mr. Sloan and to Mr. Kettering. Once more Mr. Kettering showed his ability to proceed with the minimum of reference to contract terminology.

He saw exactly what was needed: the construction of an additional laboratory building at Birmingham, which would be devoted entirely to cancer research under Dr. Skipper. He was prepared to join with the Sloan Foundation in financing the building and its operation. He was completely satisfied with the integrity and good will of the Birmingham group. This forward-looking resolution led to a quick consummation of our plans, which have now taken form in the Kettering-Meyer laboratory at the Southern Research Institute. Furthermore, the correctness of the decision has been amply borne out by the sheer genius in organization and conduct of the program displayed by Dr. Murray, Dr. Skipper, and their associates. Indeed, I feel that when the score is finally reckoned, this unit will stand high in the progress of research leading to cancer control. It is simply impossible to describe the effectiveness of this co-operation, the conduct of a program wholly without self-interest on the part of either Trustees or scientific workers. Score again a management triumph for Mr. Kettering, and his intuitive genius in selecting good people to work with, and once this selection is made to continue the program despite any obstacle and any disappointments, and without permitting interference on the part of well-meaning but ill-informed individuals. His phrase "illegitimus non carborundum" (don't let the rascals get you down), though not the best Latin, has kept us going over many apparently intolerable rough spots.

By this time Mr. Kettering had concluded that the facilities in the family home in Dayton were not adequate to forward the work in prebiological chemistry to which he wished to commit his time. Furthermore, these facilities clearly were not adequate to permit the desirable extent of co-operation with the work at the Southern Research Institute and at the Sloan-Kettering Institute. He resolved, therefore, to construct, contiguous with the Antioch campus, in Yellow Springs, Ohio, a new laboratory of some 40,000 square feet. The speed and precision with which this was planned and constructed have always been a matter of complete marvel to me, who had been through only a much more complicated construction operation. Almost overnight, the plans were completed, the contract let, and the laboratory erected.

Here, again, Mr. Kettering's ability to surround himself with a team of wholly functional individuals was most outstanding. He, and they, knew exactly what they wanted, and how to get it with the minimum of expense and of time. To see this operation develop has been a heart-warming experience. The function of the laboratory was established, the areas of fundamental research were defined, as they pertained to the goal, suitable personnel were obtained, and their efficient function was assured by ideal working arrangements. This could be done, of course, only by Mr. Kettering's ability so to constitute his Board of Trustees that they understood his wishes and were prepared to carry them out. Furthermore, by his ability to free himself of the obligations involved in accepting grants - in - aid from governmental or philanthropic organizations, he was prepared to back his ideas and his wishes, and in so doing, simplified enormously the problems of the institution. It was also heart-warming to see the great skill and thought applied to the problem of placing the laboratory and making available at Antioch ancilliary facilities for its effective use, such as students' union, and a more adequate library. Everything has been done to insure the continued useful function of the structure if at any time its use in the present program is discontinued. This is, of course, another example of Mr. Kettering's deep interest in the principle of on-the-job training, exemplified in an outstanding way by Antioch College. Whereas he has never made any effort to influence the educational policies of that institution, he has indicated, in an unmistakable fashion, by the construction of facilities, his confidence in its future and in the correctness of its plan.

This brings me pretty well up to the present as far as my contact and that of the Sloan-Kettering Institute with Mr. Kettering is concerned. For years we have dined together the first Monday of each month, on the day of the General Motors Directors meeting. We meet very frequently on other occasions, in Dayton, in Yellow Springs, in Miami, and elsewhere. We at the Institute have come to depend very greatly on his wisdom and experience. From the day of our first meeting, he has never ceased to emphasize the points upon which his own success is based and which he deems essential for the success of any organization with which he is associated. His principal point is that if one is to have a productive career in science, one must have some well-defined objective, whether this be the development of a better engine, the splitting of the atom, or the discovery of a better means for the control of cancer. Without objectives, he feels, scientific life is unsatisfactory and scientific work in general unproductive. This point of view is, of course, in sharp contrast to that so frequently enunciated in recent years, by those who believe sincerely that there should be no objective in research.

Mr. Kettering's insistence on the correctness of his position has roused considerable opposition. Much of it is based upon a fundamental misunderstanding of what he means by his statement. He is pictured by some as being opposed to fundamental research and concerned only with the pragmatic, or empiric methods. Of course, nothing could be further from the truth. In his own work, as well as in the activities of organizations with which he is associated, he is more than insistent on the conduct of the most fundamental research in continuity. No one could be more critical of the scientist who flits from peak to peak of transient and relatively unimportant observations; no one more committed to the long pull, the lifetime career in areas of particular scientific and social significance.

He has become, furthermore, deeply concerned by repetitious discussions of scientific policy which have begun to appear in the scientific press. He regards the only criterion of the effectiveness of a scientific program as its record of accomplishment and is disinclined to engage in philosophical dissertations. He has come to have the greatest impatience with the repetition of cliches concerning the rights and privileges, but never the duties, of the scientific worker. In his mind programs are good if they are productive, and if so they should be left alone. If they are not good, on the other hand, they should be discontinued. This degree of simplicity and of clarity would merit consideration by others in influential positions.

Obsolescence is a factor which says that the new thing I bring you is worth more than the unused value of the old thing. —C. F. K.

Charles Franklin Kettering

A Capsule Biography

CHARLES FRANKLIN KETTERING, inventor, manufacturer, director and former vice president of General Motors Corporation, and former head of GM's Research Laboratories, was born on a farm near Loudonville in Ashland County, Ohio, on August 29, 1876. He is the son of Jacob Kettering, deceased, and of Martha Hunter Kettering, deceased.

As a boy he attended the district school near his home and later went to Loudonville High School. After graduation from high school, Kettering was teacher of 30 children in a one-room school at Bunker Hill, Ohio. His ambition, however, was to acquire a college education and in the summer of 1896 he entered the University of Wooster to study classical languages. While there, he heard of the engineering courses offered at Ohio State University and decided to transfer.

Just before he was to enroll, however, his eyes failed as a result of overstudy, and he had to return home to wait for his vision to improve. For the next two years he was a teacher in the grade school at Mifflin, Ohio. His interest in science developed rapidly during this period as a result of experimenting in photography and electricity.

In 1898, his eyesight having improved, Kettering entered the Ohio State engineering school. In the middle of his freshman year his eyes failed again, and he took a job on a telephone line gang at Ashland, Ohio. That summer he was named as a foreman and in the fall installed a central battery telephone exchange, one of the first in Ohio.

Kettering returned to Ohio State in 1901, working as a telephone trouble shooter and installer during his spare time to support himself through college. In 1904 he was graduated with a degree in electrical engineering. He immediately joined the Inventions Department of The National Cash Register Company at Dayton, Ohio, where his first job was to electrify the cash register. From 1904 to 1909 he remained with NCR, where he made a number of highly significant contributions to the business machine field.

In 1909 Kettering, in association with E. A. Deeds, organized the Dayton Engineering Laboratories Company, later known as "Delco." Among the first of the problems to which Delco turned its attention was the auto ignition system, developing a superior type which was adopted by Cadillac. Next to follow was the world's first successful self-starter which appeared on the 1912 Cadillac. The effect of the Delco starting, ignition and lighting system on the auto industry was a major factor in the phenomenal growth of that industry during the next few years.

Kettering next developed a portable electric generator for use in isolated locations not serviced by utilities, and in 1914 the Delco Farm

Lighting System was first marketed, receiving widespread acceptance. Two years later Kettering and Deeds sold their interest in Delco to United Motors which later became a part of General Motors. Then they established the Dayton Research Laboratories, where the ignition system for the famed Liberty aircraft engine was developed. It was at this time also that Kettering's interest in engine knock developed, resulting in the discovery of anti-knock gasoline some years later. In 1920 General Motors took over Kettering's Dayton laboratories and in 1925 the laboratories were moved to Detroit.

A description of all the important inventions and discoveries which came out of Kettering's research program at GM would fill several volumes. They include, besides "Ethyl" gasoline, the synthesis of a new family of refrigerator gases; Durex bearings; quick-drying lacquer finishes for cars; quick process malleable iron; harmonic balancers; static and dynamic balancing machines; four-wheel brakes; crankcase ventilation, two-filament headlamps, special winter lubricants; extraction of bromine from sea water; engine oil coolers; two-way shock absorbers; chromium plating; Inlox rubber bushings for spring shackles, safety glass; fatigue study of gears; fixed-focus headlamps; extreme-pressure lubricants; resonance-type intake and exhaust silencers; double glass windows; the unit injector for Diesel engines; variable-speed transmissions; engine carbon removers; heat-resisting valve steel; copper-lead bearings, pearlitic malleable iron pistons; permanent-mold centrifugally-cast brake drums; pearlitic malleable iron camshafts; tellurium-treated malleable iron; wear-resistant cylinder iron; molybdenum-manganese-silicon steel; powdered iron metallurgy; grooved and tinned plated piston rings; and silver bearings.

One of the most outstanding contributions to transportation made by Kettering's laboratories is the two-cycle Diesel engine used in locomotives and stationary and mobile power plants. The same type of Diesel engines were also adopted by the Navy for submarines and many types of surface craft. Later research resulted in still smaller Diesels which now power large trucks, buses, tanks and tractors.

Kettering's widespread activities have included many other fields of endeavor in addition to industrial research. The Kettering Foundation is studying photosynthesis and has contributed much fundamental information concerning chlorophyll and the processes of plant chemistry. Another undertaking sponsored by Kettering was the World War II Fever Therapy Project which resulted in invention of the Kettering Hypertherm. Another far-reaching activity which Kettering helps support is the Sloan-Kettering Institute for Cancer Research.

On August 1, 1905, he married Miss Olive Williams of Ashland, who died in May of 1946. Their son, Eugene Williams Kettering, is director of research of Electro-Motive Division of General Motors. He and Mrs. Kettering, who live in Hinsdale, Illinois, are the parents of a son and two daughters.

LOOKING TO THE FUTURE

(Excerpts from C. F. Kettering's address at the dedication of General Motors' Technical Center)

"To me a technical center is a place where people can think and develop ideas. One thing worries me about this Technical Center. I am afraid that the people may lean too heavily on the facilities and forget that ideas are developed in the mind. If we took all the people away, it would be obvious that nothing would come out of the Technical Center.

"Facilities can work in two ways. I had a friend who had been ill a few years ago. He said, 'What am I going to do? I need to get outdoors.'

"So I suggested that he play golf, since I had never played it. He got some good golf clubs and he went out and played 18 holes. When he was through he said, 'Nobody can break 70. It took me 140 strokes.'

"But six or seven years later he broke 70, with exactly the same clubs. He didn't weigh any more, he might have weighed a little less, but he was the thing that had changed, not the clubs and not the golf course. He had a different co-ordination of thinking, of his physical being, so that he could now do in 70 strokes what used to take him 140.

"I am sure that the reaction on the personnel here in the Technical Center will be exactly the same. Whatever the people are when they come here, in succeeding years they will become better people, and these facilities will increase in value not because of their changing but because of a better understanding of what can be done with them.

"Anything that you think of today can be done, but it takes time. There is one thing that we must bring into the picture consistently: How long is it from the concept of an idea to the time we have the product in the hands of the customer?

"It may be 50 or 60 years sometimes before an idea develops. But if we will recognize that there is a definite time before an idea can become a product, provided the customers are available for it, the future is the greatest natural asset we have. You make its value, depending upon how you think.

"With willing hands and open minds, the future will be greater than the most fantastic story you can write. You will always underrate it."

Get Off Route 25, Young Man 1

"Of Course, We Can" 9

Revolution on Central Avenue 15

The First Buzz Bombs 23

The Evolution of "Ethyl" 27

"I Am An Old Pilot" 33

Detroit's Apostle of Progress 37

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