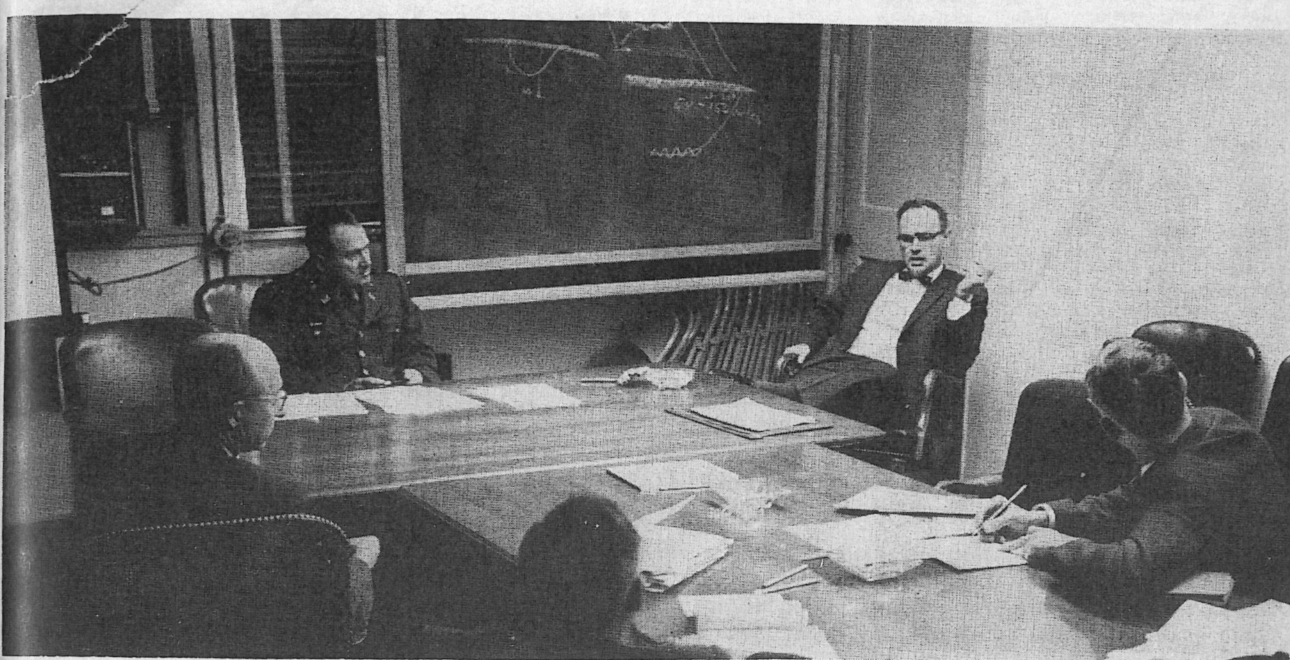


Army Engineers and AEC give ENR a special briefing on . . .

Excavating With Nuclear Bombs

Practical nuclear excavation is still several years away, but it will come sooner than any other peaceful use of nuclear explosives.

So said Army Corps of Engineers and Atomic Energy Commission spokesmen to ENR last week in a special briefing at Army Engineer headquarters in Washington.

Government engineers and scientists have reduced nuclear excavation to near-handbook simplicity in some respects. But many unknowns, technical, legal and administrative, must be explored before it becomes a practical construction tool. The technology appears possible within five years, says the AEC.

Excluding bomb technology, the engineers and scientists know more about control of crater dimensions than any other technical aspects. They know a great deal about controlling radiation fallout, one of the three major hazards, and are making progress in predicting and limiting damage from ground shock and air blast, the other two.

Costs are well enough known to make it plain that nuclear excavating may become an irresistible bargain.

The study of nuclear excavating began formally in 1957 when the AEC launched Project Plowshare, a broad effort to develop peaceful uses for nuclear explosives. Several years of informal consultation with the Corps of Engineers on construction problems culminated nine months ago in establishment of a formal Corps-AEC joint program. The Corps created the post of Assistant Director of Civil Works for Nuclear Construction Planning and assigned Lt. Col. Robert W. McBride to it. His responsibility includes a crater-study group assigned to Lawrence Radiation Laboratory, Livermore, Calif., Project Plowshare headquarters.

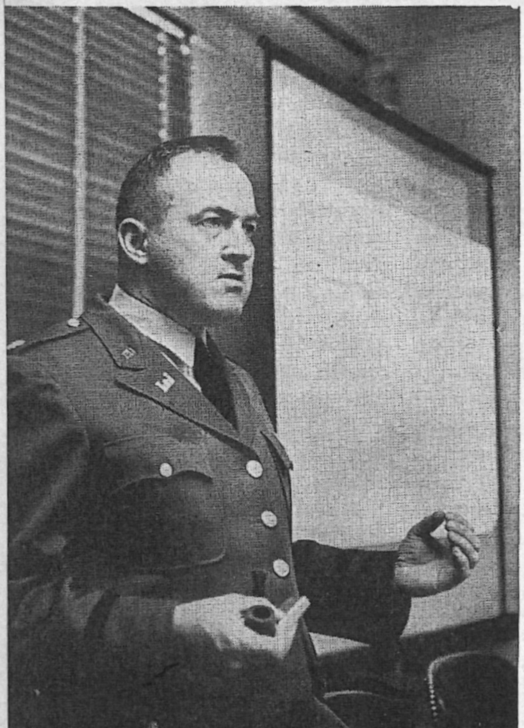
Spending on the excavation study is rising, both with increased spending on the over-all Plowshare program and as a result of taking over more of the Plowshare effort. Excavating study is taking a quarter to a third of the $9.6-million Plowshare appropriation for fiscal 1963 (ending June 30) and could take as much as half of the $16 million requested in the President's fiscal 1964 budget, according to John Kelly, Chief of the AEC's Division of Peaceful Nuclear Explosives. The Corps will spend more, too, on its collateral effort. The 1963 appropriation was $500,000. The Administration has asked for $2 million for 1964, says Colonel McBride.

AEC efforts in the joint program generally go toward device development, execution of nuclear experiments and development of basic scientific relationships. The Corps conducts corollary chemical-explosive tests and collects data for solution of engineering and construction problems, such as slope stability, permeability and construction in fractured rock. Colonel McBride says the Waterways Experiment Station and other parts of the Corps organization will take part as needed.

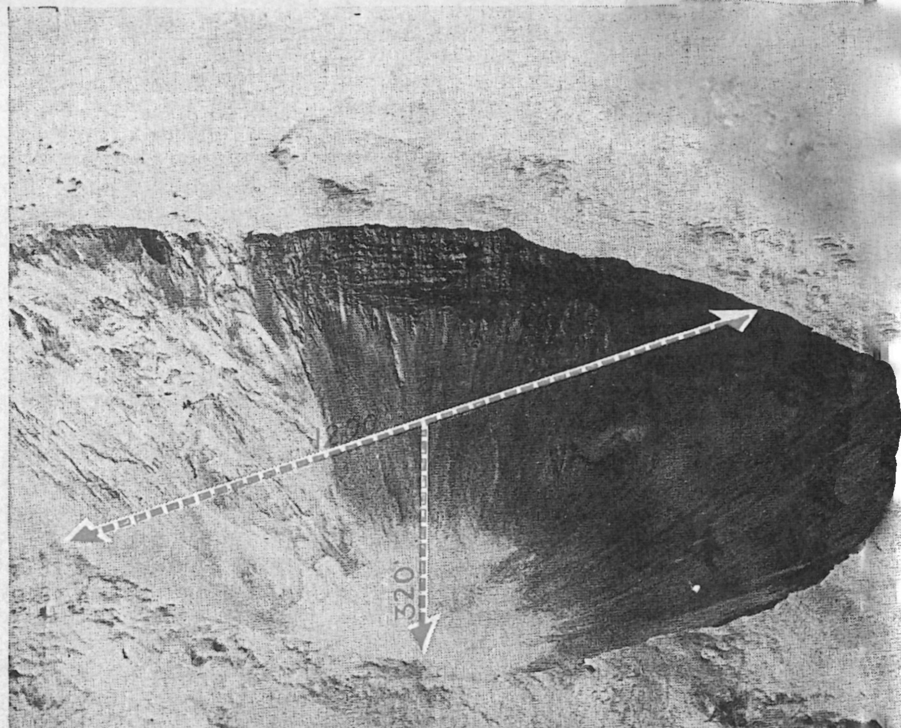
The Plowshare Division set off well over 100 chemical high-explosive shots ranging from 256 lb to 1 million lb during the three-year nuclear-test moratorium. These made it possible to establish and verify empirical relationships between energy yield, burial depth of explosive, and crater dimensions.

Crater radius and depth in desert alluvium for the range of energy yeilds tested vary according to $W^{1/3.4}$, where W is the energy yield (see curves for a 1-kiloton shot, p.15). The 100-kiloton Sedan nuclear shot in July, 1962, conformed fairly closely to this relationship too.

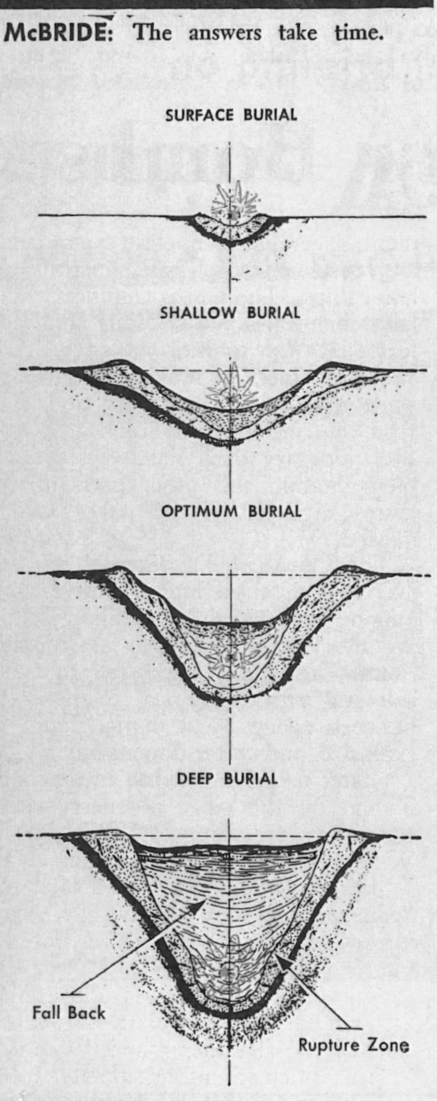
The Sedan device was Plowshare's first nuclear cratering blast. It was detonated 635 ft underground. It moved 7.5 million cu yd and left a crater 1,200 ft across and 320 ft deep (photo, p.14).



McBRIDE: The answers take time.



ONE-SHOT CRATER was made by Plowshare's 100-kiloton Sedan blast last year.



HOW BLAST DEPTH shapes crater.

The experiments have shown that charges spaced about one crater radius apart and fired simultaneously produce a ditch that differs in important respects from a row of overlapping craters. It has fairly uniform width and depth, without pronounced cusps between charges, and it is about 25% wider than the crater that one of the charges alone could form. Virtually no material is thrown out at the end of the row. This would be an advantage in blasting a channel between two bodies of water.

The channel-excavation study will be furthered this year by Project Buggy. Five 10-kiloton devices in a row will be fired simultaneously. AEC people expect the ditch to be about 2,300 ft long, 700 ft wide and 125 ft deep, with a ridge of thrown-out earth along each side.

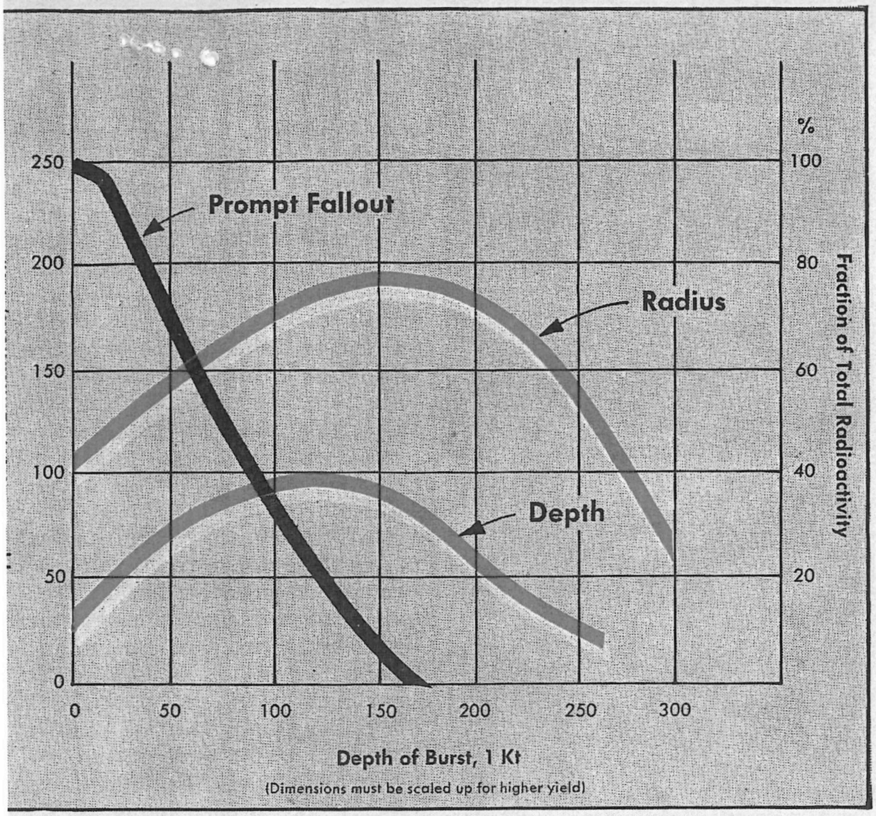
Cratering tests up to now have taken place in the lightly cemented sand and gravel characteristic of AEC's Nevada test site. Future shots will be fired in other materials to give information on whether and how the type of material affects crater dimensions. Project Schooner entails a 100-kiloton shot in granite. Project Dogsled will be a similar shot in sandstone. Project Galley will be an experiment in ditching with row charges in hard rock under hilly terrain. Project Phaeton will be a megaton shot late in the excavation study to extend cratering and fallout knowledge to that range. Project

Cratering Costs

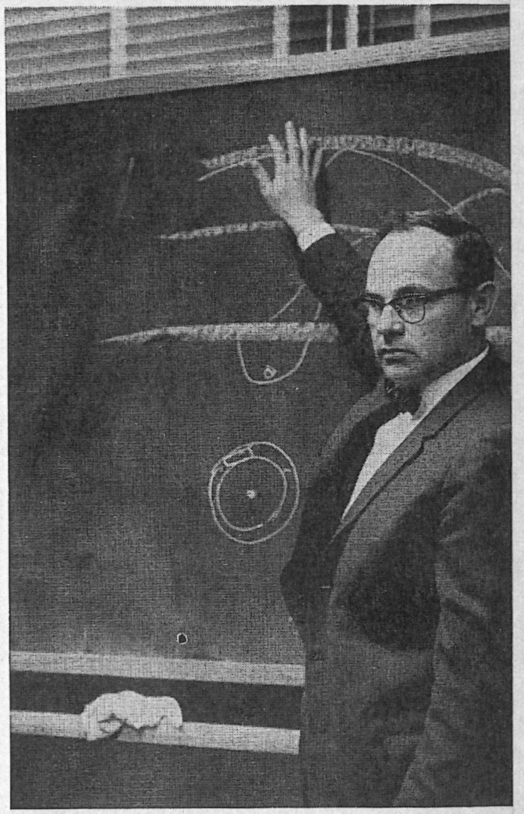
ENERGY YIELD	PLACEMENT HOLE		CRATER DIMENSIONS			ESTIMATED COSTS				
kt	Dia in.	Depth ft	Dia ft	Depth ft	Vol Millions cu yd	Explosive $000	Placement $000	Operations $000	Total $000	Per cu yd $
1	36	160	400	90	0.21	500	100	500	1,100	5.25
10	36	325	800	175	1.6	500	150	750	1,400	0.88
100	70	620	1,600	350	12	750	300	1,000	2,050	0.17
1,000	70	1,220	3,200	690	96	1,000	600	2,000	3,600	0.04

Ditching Costs

ENERGY YIELD	PLACEMENT HOLE			CRATER DIMENSIONS			ESTIMATED COSTS				
kt	Spacing ft	Dia in.	Depth ft.	Dia ft	Depth ft	Vol Millions cu yd	Explosives $000	Placement $000	Operations $000	Total $000	Per cu yd $
1	200	36	160	400	90	0.36	500	100	150	750	2.00
10	400	36	320	800	175	2.7	500	150	300	950	0.35
100	800	70	620	1,600	350	20	750	300	500	1,550	0.08
1,000	1,600	70	1,220	3,200	690	160	1,000	600	700	2,300	0.02



PTH OF BURST controls crater width and depth (ft) and radiation release.



KELLY: A lot of broken windows.

ıariot, the Alaska harbor test, is now abeyance.

Colonel McBride and Mr. Kelly emasized the progress made in controlg radioactivity. First, the fusion dees now available generate less radiotive debris than fission bombs, and scientists expect to make them n cleaner. The Sedan yield was s than 30% fission. They can make -kiloton devices with less than 10% ion. Second, the fallback in a well ced cratering shot traps most of the lioactivity. The deeper the blast, the s radioactivity escapes (see curve, ove). At optimum cratering depths oughout the range of energy yields ted so far, less than 10% of the lioactivity escapes. Only 4% esped in the Sedan shot and seven to ht-tenths of that percentage came wn in the zone of fallen earth within ouple of miles of the crater.

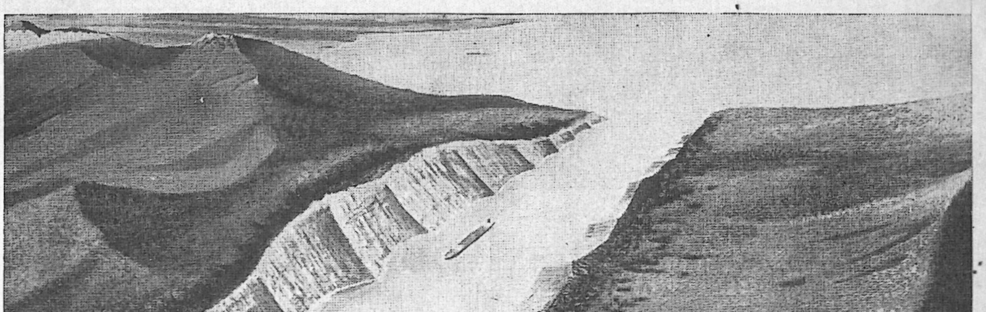
Ground shock and air blast are inly siting problems. The researchhave come up with preliminary thods of predicting accelerations imsed on structures by ground shock, t the subject requires much more idy to learn how to predict the ects of local geology. Air blast means lot of broken windows a long way m ground zero under certain condins. Mr. Kelly explained that the ublesome effect is a sound wave used upward from the crater. It s the ozonosphere and bounces back earth in an annular ring 150 to 200 les from the blast. Air blast is greatly affected by meteorological conditions, so minimizing the damage is a matter first of blast site location and second of blast timing to suit the weather.

Whoever uses nuclear excavators will get cheap dirt moving if he uses big ones, and he can't afford to use small ones, according to AEC cost predictions. He can dig for anything from 2 cents to $5.25 a cu yd (see tables).

AEC contractor laboratories estimated that a sea-level Central American canal 1,000 ft wide and 250 ft deep could be constructed with nuclear explosives for about one-third the cost and in about one-half the time it would take to build one 600 ft wide and 60 ft deep by using conventional excavation methods.

Although H-digging might sharply affect some segments of the construction industry, AEC has heard little from them except from one heavy equipment maker who wants in on the ground floor. However, fallout fear and moral objections to nuclear blasts generate strong opposition.

Neither Mr. Kelly nor Colonel McBride could offer any clue as to how nuclear excavating will be administered once it's ready for the job site, nor what the legal problems might be.



LIKELY FIRST JOB for H-excavation will be a big canal like this (note small cusps).