Operation HARDTACK

April - October 1958

Project 6.15

ELECTROMAGNETIC PULSES from LOW-YIELD BURSTS (U)

Issuance Date: August 31, 1960

HEADQUARTERS FIELD COMMAND
DEFENSE ATOMIC SUPPORT AGENCY
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

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ATOMIC ENERGY ACT 1954

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ELECTROMAGNETIC PULSES from LOW-YIELD BURSTS (U)

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second channel of each of the four oscilloscopes, to be used for timing identification of the data signal.

At some time before H-hour, the Dymec pulse shifter, which generated one pulse per second, was synchronized with WWV. At a known instant of time before H-hour, the output of the pulse shifter was fed into a Hewlett-Packard counter. This counter was used as a totalizer, to refer time to Station WWV. At H−3 seconds, the counter was stopped by removing the one-pulse-per-second input. The next pulse, at H − 2 seconds, was switched into the input of the first of two Hewlett-Packard 218A digital-delay generators, each equipped with dual-pulse unit 219B. The two delay generators were connected in a loop so that, once they were energized by an external pulse, they would maintain oscillation and produce four sequential pulses delayed in time with respect to each other. The delays were adjusted so that a pulse was repeated at each 100-μsec interval, and these pulses then triggered the sweep for each of the four cathode-ray tubes (A, B, C, and D). The sweep setting for each was adjusted to produce a sweep period of 100 to 110 μsec; this provided a small amount of overlap from tube to tube. The combined horizontal display of the four cathode-ray tubes created a calibrated 400-μsec baseline. A Warrick camera running at 20 feet per second was used to record the oscilloscope traces. Thus, a consecutive series of 400-μsec-duration traces, the beginning of each separated vertically 0.096 inch from the previous trace, was recorded on the film.

Operations. A prediction of peak negative field strength was made before each event so as to aid in setting an appropriate vertical sensitivity. The setting of the triggering level was also based on this prediction. It was hoped that the settings would be such that the reception of sferics would be held to a minimum and that the signal would have a zero-to-peak vertical deflection of about 2 cm. Field strengths were predicted by use of the formula (Reference 3):

$$E = \frac{K}{D} Y^{1/3}$$

Where: E = field strength (v/m) at distance D
D = distance from source, km
Y = expected yield, kt
K = constant

For this test, the value for K was derived empirically from analysis of the field-strength measurements of electromagnetic pulses generated by devices with a yield less than 16 kt and propagated over land at a distance less than 180 km from the source (References 2 and 4). K was found to be equal to 1,600. The estimates were expected to agree with observations within a factor of 2.

RESULTS

Table 1 presents the basic results obtained by the project.

Including the tunnel detonation, there were seven underground shots. The equipment was operative for five of them. From results in previous tests (References 2 and 3), a recording of an electromagnetic pulse from these shots was not expected; an examination of the records showed that no signal was received.

Of the nine above-ground shots, six had a yield of 0.1 kt or less. The film records for these shots showed either no deflection or no signal discernible in the oscillograms at the expected time of arrival.

Instances where there was no signal deflection were caused by inappropriate sensitivity settings owing to either of the following: (1) the sensitivity was set lower than the setting determined by use of the prediction formula, because the sferics, immediately before the time of detonation, occurred so frequently and had such high amplitudes that it would have been impossible to recognize the signal, and (2) the sensitivity was set too low because of inaccurate pretest information on the yield of some of the devices.

The signals were classed as undiscernible when the level of ambient noise recorded was so great that signal recognition was impossible. The noise was generally in the form of sferics pulses but in some cases was generated by the equipment. Spurious oscilloscope triggerings (see Figures 15 and 16) were traced to a unit used to supply a regulated dc voltage for the Cameraflex motor drive in System 2. The drive for the Cameraflex employed a thyratron-type speed control that emitted pulses which were not detected until late in the operation. This delay

TABLE 1 SUMMARY OF SHOTS AND RESULTS

X, system not in operation; ND, no deflection; T, time counter unreliable or illegible, so that signal could not be identified; S, signal identified; and U, signal undiscernible.

Shot	Date	Time	Yield	Type	Signal Detection		
					System 1	System 2	System 3
	1958		kt				
Valencia	26 Sep	1300	0.002	Underground	X	X	X
Mars	27 Sep	1700	0.013	Underground	ND	T	U
Mora	29 Sep	0605	2.0	Balloon, 1,500 ft	S	T	S
Hidalgo	5 Oct	0610	0.077	Balloon, 1,500 ft	U	T	U
Colfax	5 Oct	0815	0.0055	Underground	X	X	X
Tamalpais	8 Oct	1400	0.077	Underground	ND	T	U
Quay	10 Oct	0630	0.064	Tower, 100 ft	U	T	U
Lea	13 Oct	0520	1.5	Balloon, 1,500 ft	ND	ND	S
Neptune	14 Oct	1000	0.090	Tunnel	ND	T	U
Hamilton	15 Oct	0800	0.001	Tower, 50 ft	ND	ND	U
Logan	15 Oct	2200	5.0	Underground	ND	T	U
Dona Ana	16 Oct	0620	0.036	Balloon, 500 ft	ND	ND	U
Vesta	17 Oct	1500	0.019	Underground	ND	ND	U
Rio Arriba	18 Oct	0625	0.092	Tower, 70 ft	U	U	U
Socorro	22 Oct	0530	6.3	Balloon, 1,500 ft	S	S	S
Wrangell	22 Oct	0850	0.1*	Balloon, 1,500 ft	ND	ND	U

* Non-nuclear.

in detection occurred because the cathode-ray tube screens were hooded during the time the camera was running. This interference was subsequently eliminated.

Three above-ground shots had a yield greater than 1.0 kt. The recorded wave forms are shown in Figures 10 through 18.

The signals from two of these shots were identified on System 1. The failure during Shot Lea was attributed to a trigger sensitivity setting that was too low. The pretest information listed the shot as having a yield many times greater than the actual amount.

On System 2, the signal was identified for only one of the three shots. The reason for the failure to detect Shot Lea was the same as for System 1. The failure during Shot Mora was attributed to both the unreliability and the illegibility of the time-reference counter. The inaccuracy of the time-reference mechanism probably resulted from fluctuations in the ambient temperature in the operating van. (It is believed the inaccuracy can be eliminated by adequate temperature-control equipment.) The recordings of the time counter were illegible because of errors in focusing the Cameraflex camera.

All three shots were identified on the System 3 recordings. In spite of the inaccurate pretest information on the yield, the system detected Shot Lea. This is explained by the fact that the reception of signals was not dependent on trigger settings; a continuous-sweep display was used.

Field-Strength Calculations. The field strengths (last two columns in Table 2) were calculated with the formula (Reference 3):

$$E = \frac{SD}{H_e C \lambda}$$

Variation in Field Strength. The field strengths of wave forms recorded in System 3 were higher by a factor of 4 than field strengths recorded in Systems 1 and 2. Though this may be related to the differences in cathode-follower bandpass, the relation is not clear.

It was noted that the measurements of Systems 1 and 2 agree more closely with results of previous nuclear tests than do those of System 3. No conclusion can be made as to the cause of the differences, and the possibility of an error in operation or in calibration of a factor used in computing field strength is not discounted.

Variation with Yield. Since only three shots were detected, it is difficult to derive meaningful relations between wave-form parameters and their yields from this test alone. However, crossover-time measurements do show an increasing trend with increasing yield, which is consistent with previous test results. Further, the crossovers were relatively close to the predicted measurements, where the prediction was based on data collected from previous tests.

TABLE 2 WAVE-FORM DATA

Figure Number	System Number	Oscilloscope	Sweep Rate	Vertical Deflection Sensitivity	Time to First Crossover	Time to Second Crossover	Pulse Duration	Time to Sky Wave Arrival	Negative Peak Field Strength	Positive Peak Field Strength
			μsec/cm	v/cm	μsec	μsec	μsec	μsec	v/m	v/m
Shot Lea, (1.5 kt):										
10	3	Console	10	5.0	16.1	29.5	87.1	261.1	42.0	41.2
Shot Mora, (2.0 kt):										
11	1	2	5	0.5	11.1	22.4	47.1	*	13.1	20.4
12	1	3	20	1.0	11.4	22.4	56.3	*	14.3	20.5
13	3	Console	10	5.0	18.2	28.2	64.6	250.0	49.5	62.5
Shot Socorro, (6.3 kt):										
14	1	1	5	0.2	12.8	25.7	*	*	9.9	9.8
15	1	2	10	0.2	12.2	23.3	68.9	*	10.7	8.7
16	1	3	50	0.2	14.1	22.8	77.8	251.8	10.2	8.0
17	2	4	20	0.5	*	24.7	*	*	11.9	11.1
	2	5	20	0.5	14.1	23.4	73.8	*	11.1	9.0
18	3	Console	10	2.0	18.5	31.0	80.0	258.7	39.1	37.0

* No value.

On the other hand, field-strength measurements do not show the expected trend with increases in yield. However, measurements in other tests had considerable scatter; hence, the discrepancies were not outside the probable range of values, particularly since this analysis concerns only three shots, of the same magnitude of yield. The measured field strengths of Systems 1 and 2 agree reasonably well with the strengths determined by use of the prediction formula, being off, at most, by a factor of 1.5. This falls within the limits attributed to the prediction formula.

CONCLUSIONS

The components of the detonation locator central AN/GSS-5(XE-1) used in the test proved to be adequate for the detection and display of electromagnetic pulses of nuclear detonations.

The wave-form results of System 3, using the display component of the AN/GSS-5, demonstrate the feasibility of spreading the signal display on more than one oscilloscope, to increase the resolution of the wave form. This technique applied to detection of friendly fire can provide an accurate time-difference measurement and thereby provide for a more accurate fix on the location of the detonation.

At the range of 100 miles the detection component of the AN/GSS-5 used in this test proved to be reliable for all shots with a yield greater than 1.0 kt. It did not detect or present a discernible signal for shots with a yield of 0.1 kt or less, for the reasons related to the increase in received sferics.

The tests showed the need for an instantaneous film processor, to enable appropriate equipment adjustments to be made. Many recordings were poor because of the delay in feedback of information on the quality of the previous records. Such a processor is in development for the AN/GSS-5.

The implementation of a sferics-signal discriminator that would reject a large percentage of sferics should improve the ability of the AN/GSS-5 to detect signals of low-yield devices. Criteria upon which to base such a device appear to exist and can be capitalized upon.

The electromagnetic pulse of underground shots was undetected.

Information obtained from wave forms, particularly time to first crossover, support the observation made from previous tests that some wave-form parameters are a function of device yield. The low-frequency cutoff of the cathode-follower bandpass probably has an effect on duration measurements, e.g., time to first crossover.

RECOMMENDATIONS

An automatic sferics-signal discriminator, which would enable the pulse-detection system to reject as many sferics signals as possible, should be developed and incorporated into the detection system. This improvement would simplify locating and identifying the pulse signal.

The present system requires readjustment of the sensitivity setting and antenna compensation for each shot to be detected. In order to make the detection system more nearly automatic, circuitry which would allow for display of signals of different strengths within a fixed range of amplitudes should be developed and incorporated into the system.

Continued development of an instantaneous film processor is of prime importance for this system.

Participation in nuclear tests should continue, to test solutions to the above development problems, and to obtain additional information on the electromagnetic pulse, especially the pulse from low-yield devices.

Efforts should be made to maintain some consistency in the equipment (particularly the antenna and the cathode follower) used from test to test, in order that the relationship between wave-form characteristics and device parameters shown in each test can be more reliably combined over all tests.

REFERENCES

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